ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2

VOL. CVIII.—No. 2810.] *LONDON: FRIDAY, NOVEMBER 7, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE...9d. BY INLAND POST ... 11d.

Aveling & Porter, Ltd.,
ROCHESTER, KENT.
and 72, CANNON STREET, LONDON.
STEAM ROLLERS. ROAD LOCOMOTIVES.
STEAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 7667

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, page 33.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Henry Butcher & Co.,
VALUERS AND AUCTIONEERS
to the
ENGINEERING AND ALLIED TRADES.
ALSO FOR
PLANT AND MACHINERY. 6591
63 and 64, CHANCERY LANE, W.C. 2.

Cranes.—Electric, Steam,
HYDRAULIC and HAND.
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 7264

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 7410
See Advertisement last week, page 132.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9083

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD.,
ENGINEERS, NEWCASTLE-ON-TYNE. 7260

A Time Recorder Wanted,
State price and where can be seen.—BOX T.R., SMITH'S Advertising Agency, Ltd., 100, Fleet Street, London, E.C. 4. A 679

Petter Oil Engines.
Manufactured by 3591
PETTERS LIMITED, Engineers, Yeovil.

"Spencer-Hopwood" Patent Boilers.
Sole Makers:
W. H. SPENCER & CO., HITCHIN, HERTS.
See page 15. 7454

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9753

Electric Transporters.
S. H. HEYWOOD & CO., LTD., 7182
REDDISH.

Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY 1834
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C. 3.

Iron and Steel
Tubes and Fittings.
6520
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 84, Robertson Street, Glasgow.
See Advertisement page 197, Oct. 31.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia, 7769
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches, or Barges,
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO.,
50, Wellington Street, Glasgow. 7898

OIL FUEL APPLIANCES.
Systems
PRESSURE, AIR, STEAM.
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool; and
109, Fenchurch St., London.
Naval Outfits a Speciality.
4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 141, last week.

Cochran Boilers.
MULTITUBULAR AND CROSS-TUBE TYPES.
See page 17. 7363

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Od 3883

"Aptol" Oils
MEAN
Economy.
Henry Wells Oil Co.,
11, Haymarket, LONDON, S.W. 1. 7154

Electric Lifts
(UP TO 35 TONS.)
S. H. HEYWOOD & CO., LTD., 7183
REDDISH.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 7312

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, GLASGOW. Od 8547
Registered Offices: 103a, Cannon St., London, E.C.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 86. 7368

CO_2 Plants (CARBON DI-OXIDE)
for Chemical Wks., Mineral Water Mfrs., Breweries, and all other purposes. — AERATORS LTD., 109, Victoria St., S.W. 1 ("Transpark, London.").

Die Finished Castings
ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to AERATORS LTD., Edmonton, London, N. 18.

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C. 3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Feed Water Filters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 7726

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 7991

CHANTIERS & ATHLIERS
Augustin-Normand
91, rue de Perrey—LE HAVRE (France). 2990
Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Rubber MANUFACTURERS
Valves and Packings
GUTTA PERCHA & RUBBER, LIMITED.
Toronto Canada. 7535

Electric Cranes.
7187
S. H. HEYWOOD & CO., LTD.,
REDDISH.

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office:
3, VICTORIA STREET, WESTMINSTER, S.W. 8263

Diesel Driven Generators.
400/500 Kw., D.C., 500 or 250 volts, 230 r.p.m. in excellent condition. Low price.
Also several 170 Kw. Bellis & Morcom-Siemens GENERATING SETS, 230 volts, D.C., and Parsons TURBINES, 500 Kw., 250 volts, D.C., complete with Condenser.
MOTORS from 5/100 HP., 230/250 volts.
JENNINGS,
West Walls, Newcastle-on-Tyne. 7969

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, } Row's Patents
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 8128

Yarrow Patent Water-tube Boilers.
7166
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 7689
See Full Page Advt., page 82, Oct. 17.

Forgings.
Walter Somers & Co., Ltd.,
HALESOWEN. 7116

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 96. 2463

Taylor & Challen Presses.
8198
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement, Oct. 17.

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 7908

Micrometers
FROM
Stock.
THE
Newall Engineering Co.
(Proprietors, Peter Hooker, Ltd.),
LONDON, N. 17. 7834

Machine and Engineering
WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

Locomotive Traversers
(ELECTRIC).
7183
S. H. HEYWOOD & CO., LTD.,
REDDISH.

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND,
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. 2.
See half-page Advert. last week and next week. 7598

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
7940
See half-page Advertisement page 98, Oct. 31.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

The National Foremen's ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.

(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. A 830

All communications to— Head Offices—
H. W. REID, General Secretary. 81, High Holborn London, W.C. 1.

Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes, &c. "O" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434 Offices of Engineering.

Correspondence Tuition.—

B.Sc., Inst.C.E., Inst.M.E.; also Single Subjects by Honours B.Sc., A.M.I.C.E., etc. Fees moderate.—Address, 7879, Offices of Engineering.

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 7882

Inst.C.E., Inst.Mech.E., and

all ENGINEERING EXAMS.—A Practical Engineer, A.M.I.C.E., &c. (recently demobilised), has now resumed coaching for above by CORRESPONDENCE, after 11 years' highly successful pre-war experience. Separate subjects may be taken. Excellent testimonials. Fees moderate.—Address, A 606, Offices of Engineering.

Engineering Special Classes.

Marine & Aero-Engines, Alternating Currents, Wireless Course, Ferro-Concrete, Refrigeration, Pract. Maths. and Calculus.—PENNINGTONS, University Tutors, 284, Oxford Rd., Manchester.

TENDERS.

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

The Council invite

Tenders for the following:

(a) STATIC TRANSFORMERS.
(b) H.T. and L.T. CABLE.
(c) H.T. OIL BREAK SWITCHES.
(d) Black and Galvanised CORRUGATED IRON SHEETS.
(e) STEAM PIPING.

Full Particulars and Forms of Tender may be obtained from Mr. G. G. BELL, Borough Electrical Engineer, Electricity Department, 85, Fulham Palace Road, W.6.

Sealed Tenders, endorsed "Tender for Plant" must be delivered to the undersigned not later than Four p.m. on Thursday, the 20th November, 1919.

The Council does not bind itself to accept the lowest or any Tender.

LESLIE GORDON, Town Clerk.
Town Hall, Hammersmith, W.6.
29th October, 1919. B 366

TO ENGINEERS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD invite separate

Tenders for (1) Installation of

new STEAM BOILER in Shore Boiler House at the Training Ship "Exmouth." (2) Providing two new 50 gallon steam jacketed BOILING PANS at the Darenth Training Colony, in accordance with drawing and specifications prepared by Mr. T. Cooper, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief.

The drawing, specifications and forms of tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after Ten a.m. Monday 10th November, 1919, and the drawing, specifications and forms of tender can then be obtained upon payment of a deposit of £1 in respect of each work.

The amount of the deposit will be returned only after the receipt of a bona fide Tender sent in accordance with the instructions on the form of tender and after the specifications and drawing have been returned.

Tenders addressed as noted on the form must be delivered at the Office of the Board not later than Two p.m. on Wednesday, 26th November, 1919.

(By Order)
DUNCOMBE MANN, Clerk to the Board.
B 423

LONDON COUNTY COUNCIL.

SUPPLY OF STORES, &c.

Applications are Invited from

Persons and Firms and particularly Manufacturers, for permission to be placed on the lists of Persons and Firms from whom the Council, from time to time INVITES TENDERS for the SUPPLY of ENGINEER'S GOODS and STORES.

Applications must be made on the Official Form, copies of which, together with a statement giving further information on the subject, including the standard conditions of contract, can be obtained from the Clerk of the London County Council, County Hall, Spring Gardens, S.W. 1.

Particular attention is drawn to the fact that, when an application has been made to the Council by a person or firm for permission to be placed on the Council's List and the application has been acceded to, it is not necessary for such person or firm to apply for forms of tender, as in all suitable cases, forms of tender will be sent from time to time as issued. B 393

JAMES BIRD, Clerk of the London County Council.

COUNTY BOROUGH OF CROYDON.

SEWAGE WORKS EXTENSION—SOUTH NORWOOD FARM.

ELECTRIC MOTOR AND PUMP.

Notice is Hereby Given that the Council are prepared to receive

Tenders for the Supply,

ERECTION and MAINTENANCE in the Old Engine House of a NEW ELECTRIC MOTOR and PUMP and Connections for Pumping Sewage Sludge at the Sewage Disposal Works, South Norwood Farm.

General and Special Conditions, Particulars, Specification and Form of Tender may be obtained at the Borough Engineer's Office, Town Hall, Croydon, upon payment of a deposit of One Guinea, which will be returned upon receipt of a bona fide Tender.

Tenders on the prescribed form to be sent to me by Eleven o'clock in the forenoon of Monday, 17th day of November, endorsed "Tender for Electric Motor and Pump, South Norwood Farm."

Tenders will only be received subject to the terms of the Draft Contract deposited at my office, which may be inspected during office hours.

The Council will not be bound to accept the lowest or any Tender.

JOHN M. NEWNHAM, Town Clerk.
Town Hall, Croydon.
20th October, 1919. B 372

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (Plant and Machinery Section).

For Sale by Public Tender:—

Six ¾ in. FOUR-SPINDLE GRIDLEY AUTOMATICS.
20 No. 2 VICTORIA CAPSTAN LATHES, by Selson Engineering Co.
Four ¾ in. No. 60 NATIONAL ACME AUTOMATICS.

Lying at Messrs. Kirby Banks Screw Co., Ltd., Beeston, Leeds.

Tenders for the above must be received not later than Ten a.m., November 22nd.

Tender Forms and Permits to view, and all further information can be obtained on application to the Controller D.B. 1 (E), Charing Cross Embankment Buildings, W.C. 2.

Note.—For particulars of other Government property for sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 335

CITY OF BRADFORD.

SEWAGE DISPOSAL WORKS.

The Corporation are prepared to receive

Tenders for the following:—

CONTRACT No. 30.

For the Supply, Delivery and Erection of One WATER-TUBE BOILER, of about 4000 square feet heating surface, with Superheater, and Stoker complete.

CONTRACT No. 31.

For the Supply, Delivery, and Erection, of One FUEL ECONOMISER, suitable for an average evaporation of about 24,000 lbs. water per hour.

Further particulars and copies of Specifications may be obtained at the Offices of Mr. JOSEPH GARFIELD, M.Inst.C.E., Sewage Works Engineer, Esholt Hall, Shipley (Station: Apperley Bridge, Midland Railway).

Tenders endorsed "Esholt Sewage Disposal Works Contract No. " (30 or 31 as the case may be), must be delivered at the Office of the undersigned, not later than Nine a.m., on Wednesday, the 26th November, 1919.

The Contract will be let subject to the Fair Contracts Clauses of the Corporation, which may be seen at the Sewage Works Engineers' Office, and which the accepted Contractors will be required to sign.

The Corporation do not bind themselves to accept the lowest or any Tender.

N. L. FLEMING, Acting Town Clerk.
Town Hall, Bradford, 3rd November, 1919. B 425

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD. (Ferrous Metals Section.)

FOR SALE BY PUBLIC TENDER. CONSTRUCTIONAL STEEL WORK.

Tenders are Invited for the

following:—
About 200 Tons STEELWORK (New) exclusive of Bolts.
About 200 Tons STEELWORK (Old) exclusive of Bolts.

Lying at R.N. Airship Station, Cranwell, near Sleaford, Lincolnshire.

Forms of Tender may be obtained and the Drawings examined, by application to the DISPOSAL BOARD, Ferrous Metals Section, Room 377, Hotel Metropole, Northumberland Avenue, London, W.C.

Applications for Forms of Tender must be made not later than the 16th day of November, and the same returned on or before the 1st December, on which day at Ten o'clock the same will be examined.

The Board do not bind themselves to accept the highest or any Tender.

Production of the Form of Tender will entitle applicants to view the material as lying at above.

Note.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 409

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD.

(PLANT AND MACHINERY SECTION.)

For Sale by Public Tender,

MACHINERY AND PLANT. Tenders are invited for the following:—

Hand Power Jib Crane 9 ft., Jib 10 ft. radius, 15 cwt. Mounted on circular table.

One ton Platform Scales on wheels 32 in. square. Portable double ended grinder (emery). Air Compressor by Ingersoll Rand & Co., Type No. 12. 150 lbs. per sq. inch. Air receiver for same, also cooling tank.

One BHP. A.C. 3 phase 50 cycles, Semi-enclosed Motor, 400 volts, direct coupled to 12 in. fan.

Six BHP. A.C. Motor as above with switch and starter but without fan. One Oxygen Acetylene Generator, Cap 20 lbs., with all fittings, also Oxygen cutter with spare nozzles.

Above lying at H.M. Store, Ebor Mills, Bingley, Yorks. Tenders closing, November 26th.

CHILLED ROLLS.

Four Chilled rolls 25 in. dia. by 5 ft. 2 in. long. Footplate for wide rolls. Turning Rest for Sheet Mill.

Lying at The Albert Sheet Iron Co., Ltd., Hill Top, West Bromwich, Birmingham.

Rolling Mills, power feed, will roll from 2 B.A. to ¾ in. Present rolls take ¾ in. and 7/16 in., double friction clutch drive.

Lying at Rotax Motor Accessories, Ltd., Willesden Junction, N.W. Tenders closing, November 26th.

Large number of C.I. Tanks, some galvanized: also wood tanks, various sizes. Filter Presses, 24 chambers 24 in. sq. complete with pipes, etc. Mild Steel vessels. Platform weight machines. Air Compressors, Vacuum Pumps. Self landing and delivery hoist, 15 cwt. Electric Fans and numerous other articles.

Lying at H.M. Factory, Sutton Oak. Tenders closing, November 26th.

STEEL TUBING.

About 2500 ft. Lapwelded Steel Tube 3/16 in. thick, with Std. inserted joint for lead and yarn. Various lengths of the following bores: 18 in., 12 in., 4 in. Also a quantity of Bends, Reducers, Cocks, Thimbles.

Lying at H.M. Factory, Victoria Works, Northwich. Tenders closing; November 26th.

Conveyor in diamantied condition, complete with 695 trays, 600 ft. double endless chain and rollers. Paint Sprayer by Aerostyle & Lithos, Ltd., complete with 6 H.P. Motor and starter. Grouting Machine by Murray Worisman & Co., Piping, etc.

Lying at No. 6, N.F.F., Chilwell. Tenders closing November 24th.

Two Gasometers 9ft. dia. x 8 ft. deep single lift.

Lying at Messrs. Ardois Factory, Selby. Tenders closing, November 24th.

Portable Band Conveyors, length 24 ft., fitted with 2½ H.P. Motor by Phœnix Mfg. Co., suitable for 220 volts D.C. supply.

Stacking Machine, 36 in., fitted with two 15 H.P. Siemens Motors suitable for 220 volts, D.C. supply. Stacking height 12 ft. 0 ins.

Tenders closing, November 26th. In charge Shipping Officer, R.A.S.C., West Side, Royal Docks, Grimsby.

MOULDING MACHINES.

Two Moulding Machines for hollow pellets, each fitted with 102 moulds. Moulds contained in troughs of three rows of 17 each.

One machine fitted with two driving plates for ejecting pellets from moulds. These have been used for moulding T.N.T., but should be suitable for numerous other kinds of work.

Lying at the works of Mr. E. Cowles, Ivy Road, Hounslow. Tenders closing November 26th.

Three Cameron Slitters and rewinders for cutting fabric. Eighty cutter wheels, serrated edges.

One Unreeling, Folding and Re-winding Machine complete with motor and starter.

Lying at 44, Chichester Street, Belfast. Tenders closing November 26th.

LAUNDRY PLANT.

12 Frugal Gas Irons with bars, etc.
One Rotary Washer, 24 Wringing Machines.
Three Hydro Extractors, Mangles, Presses and other plant.

Lying at Nottingham, Coventry and Leeds. Tenders closing November 26th.

ELECTRIC COPIERS.

Five Shaw's Continuous (double) Electric Copiers.
Two Hall's do. do. do.
One Drying Machine.
Three American Washing and Drying Machines.

Lying at Hotel Cecil, London. Tenders closing November 24th.

100 Steel Jacks, 20 tons.

Lying at Woolwich. Tenders closing November 24th.

GASHOLDERS AND TANKS.

Two, each 500,000 cub. ft. capacity, complete with spiral guides, carriages, etc. Inn rlift 105 ft. x 30 ft. deep. Outer lift 107 ft. 6 ins. x 30 ft. deep. Inlet and outlet pipes 12 ins. dia. Tanks complete with platform, etc.

Lying at works of Messrs. Samuel Cutler & Sons, Ltd., Providence Iron Works, London, E. Tenders closing November 10th.

All Tenders must be received not later than Ten a.m. on the date stated.

Particulars of the above, together with permits to view can be had on application to the Controller, D.B.1. (E), Charing Cross Embankment Buildings, London, W.C.2.

Note.—For particulars of other Government property for sale see "Surplus," price 3d., at all bookstalls; or by quarterly subscription of 2/- post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W.1. B 189

MANCHESTER CORPORATION GAS DEPARTMENT.

The Gas Committee of the Manchester Corporation are prepared to receive

Offers for the Purchase and

REMOVAL of the following PLANT, which is to be disposed of in consequence of alterations in the No. 2 Retort House at their Bradford Road Gas Works, viz.:—

Two Sets Direct-driven Two-stage Air Compressors, diameter of air cylinders 11½ in. and 17½ in., Air Valves lifted mechanically, Air Cylinders water jacketed with intermediate cooler between first and second cylinder.
One Steam Cylinder, 13 in. diameter, 24 in. stroke,
Two Air Receivers, 3 ft. 4 in. diameter, 17 ft. long, with 3 in. connections to Compressors, air delivered to receiver at 70 lbs. pressure per square inch. Makers West's Gas Improvement Co., Ltd.

The above plant may be inspected and any further information may be obtained on application to the Engineer, Mr. Wm. Newbigging, at his Office, Rochdale Road Gas Works.

Form of Tender may be obtained on application to Mr. Fredk. A. Price, Superintendent, Gas Department, Town Hall, Manchester.

Tenders are to be addressed to the Chairman of the Gas Committee, Town Hall, Manchester, endorsed "Tender for Air Compressors, &c.," and must be delivered not later than 8 p.m. on Thursday, 20th November, 1919.

By Order,
THOMAS HUDSON, Town Clerk.
Town Hall, Manchester, 3rd November, 1919. B 507

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (Plant and Machinery Section).

For Sale by Public Tender.

10 ELECTRIC TRAVELLING CRANES, 7 tons. Makers, T. Smith & Sons (Rodley), Ltd., Motors by J. P. Hall & Co. Radius 14 to 20 ft. Lifting capacity 7 tons at 20 ft. radius. Jib 30 ft. steel lattice. Gauge 4 ft. 8½ in. adaptable to 7 ft. travelling wheels 24 in. dia., single flange. Axles 5½ in. dia. Speeds travelling 200 r.p.m. Hoisting fast and slow gears, 100 and 70 r.p.m. Motor 53 B.H.P. series wound, enclosed 500 volts D.C., 650 r.p.m. British Westinghouse Solenoid Break, 115 amps. Reversible Controller, automatic C.B. and other Accessories including a number of Spares. Approximate total weight 30 tons. Reg. G. 1541.

Tenders closing November 28th.

Lying at Admiralty Works, Southwick, near Brighton. (Nearest station Southwick.)

LARGE STORAGE TANKS.

One Tank 116 ft. dia., capacity 8000 tons.
One Tank 82·6 ft. dia., capacity 4000 tons. Ref. G. 1421.

Complete with Pipe Lines, &c. (separate prices to be given).

Lying at Albert Edward Dock, Newcastle-on-Tyne.

One Tank 80 ft. dia. by 30 ft. deep of Siemens Martin Steel equal to Lloyds tests. Capacity 3760 tons. Pipe Lines &c. (separate offer to be given). Ref. G. 1331.

Tenders closing November 28th.

C.-I. Pipes, 5, 6, 8, 10, 12, 15 in. dia. Sluice Valves. Expansion Joints. Reducing Pipes, Bends and other Accessories.

Lying at Hendon Road Reservation—adjacent to Alexandra Dock, Hull.

Plans of Tanks can be seen at this office.

LOCOMOTIVES.

Two Standard gauge Locos., Kimberley and Hercules, by Manning Wardle & Co.. 6 ft. saddle, tank 130 lb. per sq. in., 12 in. by 17 in. stroke, wheel base 10 ft. 7 in. Weight 17½ ton approx. empty. Ref. 1127.

Closing November 28th.

Lying at Royal Arsenal, Woolwich.

Full particulars and tender forms can be had on application to the CONTROLLER, D.B.1.(E), Charing Cross Embankment Buildings, London, W.C. 2.

Note.—For particulars of other Government Property for sale, see *Surplus*, price 3d. at all bookstalls, or by quarterly subscriptions of 2s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 376

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of Engineering.

METROPOLITAN BOROUGH OF LAMBETH.

The Lambeth Borough Council invites

Applications for the Appointment of JUNIOR ENGINEERING

DRAUGHTSMAN in the Borough Engineer's Department, at a salary of £102 12s. per annum, rising by approximate increases of £10 to maximum of £153 18s.

There will also be paid during the pleasure of the Council a War Bonus and Percentage Addition on the commencing salary above-mentioned, which at the moment, amounts to £80 10s. 5d. per annum.

Candidates must have had experience in the Office of a Municipal Authority, Contractor or Civil Engineer, and must be neat Draughtsmen, able to use the level and make surveys, and be not more than 26 years of age.

Forms of application can be obtained on sending a stamped addressed foolscap envelope to Mr. H. E. ANDERSON, C.B., Borough Engineer, Town Hall, Brixton Hill, S.W. 2.

Applications, accompanied by not more than three testimonials must be delivered to the undersigned not later than Twelve o'clock noon, on Wednesday, the 19th of November, 1919.

Canvassing directly or indirectly is strictly prohibited.

BRUCE PENNY, Town Clerk.
Lambeth Town Hall, Brixton Hill, S.W. 2.
3rd November, 1919. B 476

A COMPLETE THEORY OF THE SCREW PROPELLER WORKING IN AIR.

By M. A. S. Riach, F.R.Ae.S., Assoc. Inst.N.A.

(*Continued from page* 363.)

We first of all require to plot a series of graphs of S and V. The right-hand side of the slip equation can be put into the form :

$$S \cdot (V + S/2) \cdot [V + S/2 + \tfrac{2}{3} \cdot \pi \cdot n \cdot D \cdot \tan \gamma^1]$$

and this is equal to :

$$\frac{2{,}200 \cdot H}{\pi \cdot \rho \cdot D^2}$$

The simplest procedure is now to solve formally for V, instead of for S, which involves the solution of a cubic equation. We thus get :

$$S \cdot (V + S/2)^2 + S \cdot (V + S/2) \cdot \tfrac{2}{3} \cdot \pi \cdot n \cdot D \cdot \tan \gamma^1 = \frac{2{,}200 \cdot H}{\pi \cdot \rho \cdot D^2}$$

$$\therefore S \cdot V^2 + S^2 \cdot V + \frac{S^3}{4} + \left(V \cdot S + \frac{S^2}{2}\right) \cdot \frac{2}{3} \pi \cdot n \cdot D \cdot \tan \gamma^1 = \frac{2{,}200 \cdot H}{\pi \cdot \rho \cdot D^2}$$

For simplicity put :

$$\frac{2}{3} \cdot \pi \cdot n \cdot D \cdot \tan \gamma^1 = \beta_1$$

and

$$\frac{2{,}200 \cdot H}{\pi \cdot \rho \, D^2} = \beta_2$$

$$\therefore S \cdot V^2 + V \cdot S \cdot (S + \beta_1) + \frac{S^2}{4} \cdot (S + 2\,\beta_1) - \beta_2 = 0.$$

$$\therefore V = \frac{-S \cdot (S + \beta_1) \pm \sqrt{(S \cdot \beta_1^2 + 4 \cdot \beta_2) \cdot S}}{2 \cdot S}$$

Since V is essentially a positive quantity, we retain only the positive sign in the quadratic, viz. :—

$$V = \frac{-S \cdot (S + \beta_1) + \sqrt{S \cdot (S \cdot \beta_1^2 + 4 \cdot \beta_2)}}{2 \cdot S}$$

Take now same ordinary values for β_1 and β_2. Let $\beta_1 = 16$, $\beta_2 = 440{,}000$.

$$\therefore V = \frac{-S \cdot (S + 16) + \sqrt{S \cdot (S \cdot 256 + 1{,}760{,}000}}{2 \cdot S}$$

$$= \frac{-S \cdot (S + 16) + 1{,}324 \cdot \sqrt{S \cdot \left(1 + \frac{256 \cdot S}{1{,}760{,}000}\right)}}{2 \cdot S}$$

$$\therefore V = \frac{-S \cdot (S + 16) + 1{,}324 \cdot \sqrt{S \cdot \left(1 + \frac{S}{6{,}880}\right)}}{2 \cdot S}$$

Hence neglecting $\frac{S}{6{,}880}$ with respect to 1, we get :—

$$\therefore V = \frac{-S \cdot (S + 16) + 1{,}324 \cdot \sqrt{S}}{2 \cdot S}$$

We can now form a table of S and V., viz. :—

S	0	10	20	30	40	50
V	∞	196	130	98	76	60

The above table shows the general way in which S varies with V. The general equation for V can be simplified :—

$$V = \frac{-S \cdot (S + \beta_1) + 2 \cdot \sqrt{\beta_2} \cdot \sqrt{S \cdot \left[1 + \frac{\beta_1^2}{4 \cdot \beta_2} \cdot S\right]}}{2 \cdot S}$$

The criterion is therefore the value of $\left[\frac{\beta_1^2}{4 \cdot \beta_2}\right]$ compared to unity. In the above case it was seen to be neglible. If we neglect it in every case, we get :—

$$V = \frac{-S \cdot (S + \beta_1) + 2 \cdot \sqrt{\beta_2} \cdot \sqrt{S}}{2 \cdot S}$$

The value of

$$\frac{\beta_1^2}{4 \cdot \beta_2}$$

is seen to be equal to

$$\frac{\beta_1^2}{4 \cdot \beta_2} = \frac{\pi^3 \cdot \rho \cdot D^4 \cdot n^2 \cdot \tan^2 \gamma^1}{19{,}800 \cdot H}$$

a fraction which is in most cases negligible compared to unity. The above formula, however, enables this value to be found in any given case if necessary.

We shall at present be satisfied with the approximation :

$$V = \frac{-S \cdot (S + \beta_1) + 2 \cdot \sqrt{\beta_2} \cdot \sqrt{S}}{2 \cdot S}$$

where β_1 measures the tan γ^1 effect.

In generalising this new process of design, plot graphically S against V from the formula for several values of β_2, and do this for several separate sheets, each sheet having a different β_1 value, or *vice versa*.

The next step in the analysis is to find the correct values of A^1 for each radius along the blade length. To achieve this, we return to the formula already given for S, viz. :

$$S = \frac{2 \cdot C \cdot [\tan A^1 - \tan A]}{1 + \tan A^1 \cdot \tan (A^1 + \gamma^1)}$$

but it is necessary to obtain a solution for A^1 from this expression. This is given by

$$\text{Tan } A^1 = \frac{C \cdot [1 + \tan A \tan \gamma^1]}{S + 2 \cdot C \tan \gamma^1} \pm \frac{\sqrt{C^2 [1 + \tan A \cdot \tan \gamma^1]^2 - [S + 2 \cdot C \tan \gamma^1] \cdot [S + 2\,C \tan A)}}{S + 2\,C \tan \gamma^1}$$

where $C = 2 \cdot \pi \cdot n \cdot x$; $\tan A = \frac{V}{C}$; and $\tan \gamma^1$ is constant.

This approximates to the simpler form :

$$\text{Tan } A^1 = \frac{C \pm \sqrt{C^2 - [S + 2 \cdot C \cdot \tan \gamma^1] \cdot [S + 2 \cdot C \cdot \tan A]}}{S + 2 \cdot C \cdot \tan \gamma^1}$$

and the value of S has been found from the previous formula. Writing $\frac{V}{C}$ for tan A, this becomes

$$\text{Tan } A^1 = \frac{C \pm \sqrt{C^2 - [S + 2 \cdot C \cdot \tan \gamma^1] \cdot [S + 2 \cdot V]}}{S + 2 \cdot C \cdot \tan \gamma^1}$$

Hence we can plot A^1 against S or V for several values of C, or *vice versa*. In practice, when designing an airscrew, it is usually sufficient to take sections every 6 in. or 8 in. along the blade. Hence an 8-ft. diameter airscrew will require, say, six or seven sections, neglecting all radii within 1 ft. of the boss centre.

Hence take values of x from $\frac{D}{8}$ to $\frac{D}{2}$, or values of $h \cdot x$ from, say, D to 15 . D, in steps of D, or, say, from 10 to 200 in stages of 10, *i.e.*, values of C from 60 to 1200, in stages of 60. Probably from 100 to 1,000 in stages of 100 would be sufficient. Thus C = 100, 200, 300, 400, 500, 600, 700, 800, 900, 1,000. The value of tan γ^1 might be taken at about 0·05 in. all the cases.

We can then immediately plot A^1 against V or S_1, taking the value of S or V, in either case, from the previous formula since S is a function of V.

This gives the correct values for A^1 along the blade. The next point is to settle the total chord angles ϕ, which are connected with the A^1 angles by the relation $\phi_x = A^1{}_x + a^1{}_x$, $a^1{}_x$ being the angle of attack of the blade section at a radius x.

To find $a^1{}_x$ we employ the third and final formula, viz. :

$$N \cdot b \cdot cy^1 = 4\,\pi\,x \cdot \sin A^1 \cdot \cos^2 A^1 \cdot [\tan A^1 - \tan A]$$

$$\therefore n \cdot N \cdot b \cdot cy^1 = 2 \cdot \sin A^1 \cdot \cos^2 A^1 \cdot [C \cdot \tan A^1 - V]$$

From which plot $[n \cdot N \cdot b \cdot c\,y^1]$ against C or A^1, &c.

This final curve settles the values of $n \cdot N \cdot b \cdot c\,y^1$ for each radius along the blade of the airscrew. Hence as n and N are known to start with $[b \cdot c\,y^1]$ is known at all radii. Thus if b, the chord widths of the blade, has been previously settled, $c\,y^1$ is found and *vice versa*. Knowing $c\,y^1$ and the type of section, a^1 is also known and hence ϕ_1.

Example of the Application of the Foregoing Method to a Particular Case.

It is required to design an airscrew for 130-h.p. motor, revolving at 1,200 r.p.m., the aeroplane having a flight speed of 110 miles an hour, the diameter of the airscrew to be 8 ft. (Take tan $\gamma^1 = 0{\cdot}05$ throughout.)

Hence :

$$H = 130,\ n = 20,\ V = 161,\ D = 8,\ \rho = {\cdot}00238.$$

Find values of β_1 and β_2, viz. :

$$\beta_1 = \tfrac{2}{3} \cdot \pi \cdot n \cdot D \cdot \tan \gamma^1 = \tfrac{2}{3} \cdot \pi \cdot 8 \cdot 1 = 16{\cdot}8$$

$$\beta_2 = \frac{2{,}200 \cdot H}{\pi \cdot \rho \cdot D^2} = 600{,}000.$$

The criterion

$$\frac{\beta_1^2}{4 \cdot \beta_2} = \frac{(16{\cdot}8)^2}{4600{,}000} = \frac{1}{8{,}500}$$

is sufficiently small to be neglected. Hence we may employ the approximate equation for S. Thus :

$$V = \frac{-S \cdot (S + \beta_1) + 2 \cdot \sqrt{\beta_2} \cdot \sqrt{S}}{2 \cdot S} = 161.$$

$$\therefore \frac{-S \cdot [S + 16{\cdot}8] + 1{,}550 \cdot \sqrt{S}}{S} = 322.$$

By trial and error, this gives S = 19 approximately. Applying this value to find A^1, we have :

$$\tan A^1 = \frac{C - \sqrt{C^2 - [S + 2 \cdot C \cdot \tan \gamma^1] \cdot [2\,V + S]}}{S + 2 \cdot C \cdot \tan \gamma^1}$$

$$\therefore \tan A^1 = \frac{C - \sqrt{C^2 - \left[19 + \frac{C}{10}\right] \cdot 341}}{19 + \frac{C}{10}}$$

Take values of x of : 1·5 ft., 2 ft., 2·5 ft., 3 ft., 3·5 ft., 4 ft., *i.e.*, of $C = 2\,\pi\,n\,x = 188, 251, 314, 377, 440, 502$.

Hence we get the following table of values :

x	1·5	ft. 2	ft. 2·5	ft. 3	ft. 3·5	ft. 4	ft.
C	188	251	314	377	440	502	
tan A^1 ..	1	·725	·575	·477	·397	·354	
A^1 ..	dg. 45	dg. m. 35 56	dg. m. 29 54	dg. m. 25 30	dg. m. 21 39	dg. m. 19 30	

And finally we find the values of $N \cdot b \cdot cy^1$ for each C value taken above, from the relation :—

$$n \cdot N \cdot b \cdot cy^1 = 2 \sin A^1 \cdot \cos^2 A^1 \cdot [C \cdot \tan A^1 - V]$$

continuing the above table, we get :

A^1	dg. 45	dg. m. 35 56	dg. m. 29 54	dg. m. 25 30	dg. m. 21 39	dg. m. 19 30	
Sin A^1	·7071	·587	·4985	·4305	·369	·3338	
Cos A^1	·7071	·81	·867	·9026	·93	·9426	
2 sin A^1 . cos^2 A^1 ..	·71	·77	·75	·7	·64	·59	
C . tan A^1—V ..	27	21	19	19	14	17	
$n \cdot N \cdot b \cdot cy^1$ ..	19·2	16·2	14·3	13·3	9	10	
$N \cdot b \cdot cy^1$	ft. ·96	ft. ·81	ft. ·715	ft. ·665	ft. ·45	ft. ·5	

The whole of the foregoing calculations for this example did not occupy the writer more than 2 hours, which could probably be easily reduced to half that period by an expert computator working continuously. Since we can make [N] either 2 or 4, *i.e.*, the airscrew may have either two or four blades, depending upon strength considerations, the above values will be for, say, four blades :—

x	ft. 1·5	ft. 2	ft. 2·5	ft. 3	ft. 3·5	ft. 4	ft.
$b \cdot cy^1$	·24 ins.	·20 ins.	·18 ins.	·166 ins.	·11 ins.	·125 ins.	
$b \cdot cy^1$	2·88	2·4	2·16	2·	1.32	1·5	

We may now accommodate the values of b, the blade width at any radius x, to suit these values. Suppose we make the blade 7 in. in width for the whole length of the blade, then the $c\,y^1$ values will be :—

x ..	ft. 1·5	ft. 2	ft. 2·5	ft. 3	ft. 3·5	ft. 4	
$c\,y^1$ ..	·412	·343	·308	·286	·189	·214	in absolute units.

This is a very fair and representative series of $c\,y^1$ values, corresponding to an angle of attack for each section of about 2 deg.

This is so because the section of the blade changes and becomes fatter as we approach the boss. In this example therefore we can take the angles of attack along the blade to be approximately 2 deg. everywhere, *i.e.*, at all radii.

Hence the final chord angles ϕ will be :—

x ..	ft. 1·5	ft. 2	ft. 2·5	ft. 3	ft. 3.5	ft. 4
ϕ_x ..	dg. 47	dg. 38	dg. 32	dg. 27½	dg. 23½	dg. 21½

because the ϕ angles are obtained by adding the angles of attack to the A^1 angles, viz. :—

$$\phi_x = A^1{}_x + a^1$$

We have now completed the design of the air screw all that remains to be done is its drawing out and "fairing-up."

Efficiency of System.

The foregoing analysis has established certain fundamental equations for designing airscrews with a minimum of calculation whilst retaining a sufficiently high degree of accuracy. These equations can be made the basis of a series of graphical

charts by which practically the whole of the calculations usually necessary may be avoided. This process will be described later. At present we are concerned with determining the efficiency formulæ for airscrews having a constant slip velocity across the blade length.

General Analysis for Efficiency.

Useful work axially per second

$$= \int d\,M\,.\,S\,.\,V = V\,.\,S\,.\int d\,M$$

Required work to produce above per second

$$= \int d\,M\,.\,\sigma\,.\,C$$

Hence efficiency of system

$$= \frac{V\,.\,S\,.\int d\,M}{\int d\,M\,.\,\sigma\,.\,C}$$

$$\therefore\ \eta^1 = \frac{V\,.\,S\,.\int (C-\sigma/2)\,.\,d\,C}{\int \sigma\,.\,C\,.\,(C-\sigma/2)\,.\,d\,C}$$

The integral in the denominator has already been found, hence we are concerned only with the integral :—

$$\int (C-\sigma/2)\,.\,d\,C$$

$$= \tfrac{1}{2}\,.\int d\,C\,.\left[C + V\,.\tan\gamma^1 \mp \lambda\right] \text{ as before}$$

$$= \tfrac{1}{2}\,.\int d\,C\,.\left[C + V\,.\tan\gamma^1 \mp \sqrt{C^2 - B_4\,.\,C + B_5}\right]$$

$$= \tfrac{1}{2}\left[\frac{C^2}{2} + V\,.\tan\gamma^1\,.\,C\right]_0^{\pi\,.\,n\,.\,D} \mp \tfrac{1}{2}\,.\int_0^{\pi\,.\,n\,.\,D} d\,C\,.\,\sqrt{C^2 - B_4\,.\,C + B_5}$$

$$= \tfrac{1}{2}\,.\left[\frac{\pi^2\,.\,n^2\,.\,D^2}{2} + V\,.\tan\gamma^1\,.\,\pi\,.\,n\,.\,D\right] \mp \tfrac{1}{2}\,.\int_0^{\pi\,.\,n\,.\,D} d\,C\,.\,\sqrt{C^2 - B_4\,.\,C + B_5}$$

we therefore concentrate on the evaluation of the integral :—

$$\int d\,C\,.\,\sqrt{C^2 - B_4\,.\,C + B_5}$$

The solution of this becomes :—

$$\tfrac{1}{2}\,.\left(C - \frac{B_4}{2}\right)\,.\,\sqrt{C^2 - B_4\,.\,C + B_5} + \tfrac{1}{2}\,.\left(B_5 - \frac{B_4^2}{4}\right)\,.\log_e\left[C - \frac{B_4}{2} + \sqrt{C^2 - B_4\,.\,C + B_5}\right]$$

Taken between the limits $\pi\,.\,n\,.\,D$ and 0.

$$= \tfrac{1}{2}\,.\left(\pi\,.\,n\,.\,D - \frac{B_4}{2}\right)\,.\,\sqrt{\pi^2\,.\,n^2\,.\,D^2 - B_4\,.\,\pi\,.\,n\,.\,D + B_5} + \tfrac{1}{2}\,.\left(B_5 - \frac{B_4^2}{4}\right).\log_e\left[\pi\,.\,n\,.\,D - \frac{B_4}{2} + \sqrt{\pi^2\,.\,n^2\,.\,D^2 - B_4\,.\,\pi\,.\,n\,.\,D + B_5}\right] - \tfrac{1}{2}\,.\left(-\frac{B_4}{2}\right)\,.\,\sqrt{B_5} - \tfrac{1}{2}\,.\left(B_5 - \frac{B_4^2}{4}\right)\,.\log_e\left[-\frac{B_4}{2} + \sqrt{B_5}\right]$$

Now apply the test to find which terms may be neglected, viz. :—

Let

$$B_4 = 18.,\ B_5 = -6736.,\ \pi\,.\,n\,.\,D = 500.;$$

Then

$$= \tfrac{1}{2}\,.\left(500 - 9\right)\,.\,483 + \tfrac{1}{2}\,.\left(-6.30 - 81\right)\,.\log_e\left[\quad\right] + \frac{18}{4}\,.\,\sqrt{-6736} - \tfrac{1}{2}\,.\left(-6817\right)\,.\log_e\left[\quad\right]$$

$$= 118{,}400 - 3409\log_e\left[\quad\right] + 3400\log_e\left[\quad\right]$$

Hence we retain only the term

$$\tfrac{1}{2}\,.\left[\pi\,.\,n\,.\,D - \frac{B_4}{2}\right]\,.\,\sqrt{\pi^2\,.\,n^2\,.\,D^2 - B_4\,.\,\pi\,.\,n\,.\,D + B_5}$$

which is equal to

$$\tfrac{1}{2}\,.\left[\pi\,.\,n\,.\,D - \tan\gamma^1\,.\,(V+S)\right]\,.$$

$$\sqrt{\pi^2\,.\,n^2\,.\,D^2 - 2\,.\,\pi\,.\,n\,.\,D\,.\tan\gamma^1\,.\,(V+S) + V^2\,.\tan^2\gamma^1 - S\,.\,(2\,.\,V+S}$$

The complete expression is therefore

$$\tfrac{1}{2}\,.\left[\frac{\pi^2\,.\,n^2\,.\,D^2}{2} + \pi\,.\,n\,.\,D\,.\,V\,.\tan\gamma^1\right] + \tfrac{1}{4}\,.\left[\pi\,.\,n\,.\,D - \tan\gamma^1\,.\,(V+S)\right]\,.$$

$$\sqrt{\pi^2\,.\,n^2\,.\,D^2 - 2\,.\,\pi\,.\,n\,.\,D\,.\tan\gamma^1\,.\,(V+S) - S\,.\,(2\,.\,V+S) + V^2\tan^2\gamma^1}$$

for the approximate value of

$$\int_o^{\pi\,.\,n\,.\,D} (C - \sigma/2)\,.\,d\,C$$

And the approximate value of

$$\int_o^{\pi\,.\,n\,.\,D} \sigma\,.\,C\,.\,(C - \sigma/2)\,.\,d\,C$$

is given by

$$\frac{S\,.\,(V + S/2)\,.\,\pi^2\,.\,n^2\,.\,D^2}{2} + \frac{\pi^3\,.\,n^3\,.\,D^3\,.\,S\,.\tan\gamma^1}{3}$$

The efficiency of the complete screw is then the quotient of these two integrals multiplied by V . S. As an example we may calculate from this formula the efficiency of the airscrew previously designed. Where :

$$S = 19,\ V = 161,\ n = 20,\ D = 8,\ \tan\gamma^1 = \cdot 05$$

the value of the numerator will be

$$\tfrac{1}{2}\,.\left[\frac{126{,}500 + 4{,}040}{130{,}540}\right] + \tfrac{1}{4}\,.\left[\frac{502 - 9}{493}\right]\,.$$

$$\sqrt{253{,}000 - 9{,}050 - 6{,}500 + 65}$$

$$= 65{,}270 + 60{,}000 = 125{,}270$$

Hence the numerator is 125,270. The denominator is :

$$= \frac{19\,.\,(161 + 9\cdot 5)\,.\,(502)^2}{2} + \frac{(502)^3\,.\,19.}{3.20}$$

$$= \frac{19 \times 170.5 \times (502)^2}{2} + \frac{(502)^3 \times 19}{60}$$

$$= \frac{409{,}000{,}000 + 40{,}200{,}000}{40{,}200{,}000}$$

$$= \frac{}{449{,}200{,}000}$$

Hence the efficiency

$$= \frac{125{,}270 \times 161 \times 19}{449{,}200{,}000}$$

$\therefore$ Efficiency $= \cdot 855 = 85\tfrac{1}{2}$ per cent.

A remarkably high figure. This high value is obtained by the high value of V and the small value of S. Had we ignored the drag resistance altogether and employed the original ideal formula of R. E. Froude, viz. :

$$\eta = \frac{V}{V + S/2},$$

we should have got a value of $94\tfrac{1}{2}$ per cent. efficiency : The foregoing value of $85\tfrac{1}{2}$ per cent. efficiency shows the beneficial effect of keeping the slip constant over the blade length. High efficiencies may always be expected with high flight velocities and small engine horse-power, so long as a reasonably large diameter screw is employed. It is to be noticed in passing that the $\left(\frac{V}{n\,.\,D}\right)$ ratio is in this case a high one (unity), and with such a value one would naturally expect a high percentage efficiency. The difference between the actual efficiency, $85\tfrac{1}{2}$ per cent., and the ideal value of Froude, $94\tfrac{1}{2}$ per cent., is due almost entirely to the tan γ^1 effect, *i.e.*, to the drag losses on the screw blades.

An approximate formula for the total efficiency of an airscrew having a constant slip velocity along its blade length may be obtained very simply as follows :

$$\frac{\text{Axial thrust} \times \text{velocity}}{550 \times \text{efficiency}} = \text{Brake horse power}$$

$$\therefore\ \eta^1 = \frac{T\,.\,V}{550\cdot H}$$

Also

$$H = \frac{\pi\,.\,\rho\,.\,D^2\,.\,S\,.\,(V + S/2)^2\,.\,\psi}{2{,}200}$$

And

$$T = \frac{\pi}{4}\,.\,\rho\,.\,D^2\,(V + S/2)\,.\,S \text{ approximately.}$$

$$\therefore\ \eta^1 = \frac{V}{V + S/2}\,.\,\frac{1}{\psi}$$

$$= \frac{V}{V + S/2}\,.\,\frac{1}{\left[1 + \frac{2\,.\,\pi\,.\,n\,.\,D\,.\tan\gamma^1}{3\,.\,(V + S/2}\right]}$$

$$\therefore\ \eta^1 = \frac{V}{V + S/2 + 2/3\,.\,\pi\,.\,n\,.\,D\,.\tan\gamma^1}$$

$$= \frac{1}{1 + \frac{1}{2}\left(\frac{S}{2\,.\,V}\right) + 2/3\,.\,\pi\,.\tan\gamma^1\,.\left(\frac{n\,.\,D}{V}\right)}$$

Hence writing

$$Z = \left(\frac{V}{n\,.\,D}\right),\ \text{and}\ y = \left(\frac{S}{V}\right),$$

we get

$$\therefore\ \eta^1 = \frac{1}{1 + \left(\frac{y}{2}\right) + 2/3\,.\,\pi\,.\tan\gamma^1\left(\frac{1}{Z}\right)}$$

where y is the slip ratio, and z the effective pitch ratio.

Now as the diameter D of the propeller increases, other things remaining constant, the value of z decreases and the value of y also decreases. Hence the efficiency η^1 becomes less due to decrease of Z and greater due to decrease of y, so that these two effects are opposite and there will therefore be a maximum value of η^1 for some particular value of D.

The above equation may be written :

$$\eta^1 = \frac{6\,.\,Z}{6\,.\,Z + 3\,.\,y\,.\,Z + 4\,.\,\pi\,.\tan\gamma^1}$$

Now returning to the brake horse-power equation, viz. :

$$\frac{2{,}200\,.\,H}{\pi\,.\,\rho\,.\,D^2} = S\,.\,(V + S/2)^2\left[1 + \frac{2\,.\,\pi\,.\,n\,.\,D\,.\tan\gamma^1}{3\,.\,(V + S/2)}\right]$$

$$= S\,.\,(V + S/2)\,.\left[V + \frac{S}{2} + 2/3\,.\,\pi\,.\,n\,.\,D\,.\tan\gamma^1\right]$$

$$= y\,.\,V\,.\left(V + \frac{y\,.\,V}{2}\right)\,.\left[V + \frac{y\,.\,V}{2} + 2/3\,.\,\pi\,.\,n\,.\,D\,.\tan\gamma^1\right]$$

$$= y\,.\,V^3\,.\left(1 + \frac{y}{2}\right)\,.\left[1 + \frac{y}{2} + 2/3\,.\,\pi\,.\tan\gamma^1\,.\left(\frac{1}{Z}\right)\right]$$

$$= y\,.\,V^3\,.\left(\frac{2 + y}{12\,.\,Z}\right)\,.\left[6\,.\,Z + 3\,.\,y\,.\,Z + 4\,.\,\pi\,.\tan\gamma^1\right]$$

$$\therefore\ \frac{2{,}200\,.\,H}{\pi\,.\,\rho\,.\,D^2\,.\,V^3} = \frac{y\,.\,(2 + y)}{12\,.\,Z}\,.\left[6\,.Z + 3\,.\,y\,.\,Z + 4\,.\,\pi\,.\tan\gamma^1\right]$$

Now, from the efficiency equation :—

$$\eta^1\,.\,6\,.\,Z + \eta^1\,.\,3\,.\,y\,.\,Z + \eta^1\,.\,4\,.\,\pi\,.\tan\gamma^1 = 6\,.\,Z$$

$$\therefore \eta^1\,.\,3\,.\,y\,.\,Z = 6\,.\,Z - \eta^1\,.\,(6\,.\,Z + 4\,.\,\pi\,.\tan\gamma^1)$$

$$\therefore y = \frac{6\,.\,Z - \eta^1\,.\,(6\,.\,Z + 4\,.\,\pi\,.\tan\gamma^1)}{3\,.\,\eta^1\,.\,Z}$$

Hence substituting this value of y in the B.H.P. equation, we get :—

$$\frac{2{,}200\,.\,H}{\pi\,.\,\rho\,.\,D^2\,.\,V^3} = \frac{6\,.\,Z - \eta^1\,(6\,.\,Z + 4\,.\,\pi\,.\tan\gamma^1)}{12\,.\,Z\,.\,3\,.\,\eta^1\,.\,Z}\,.\,\frac{6\,.\,Z - 4\,.\,\pi\,.\tan\gamma^1\,.\,\eta^1}{3\,.\,\eta^1\,.\,Z}\,.\left[6\,.\,Z + 4\,.\,\pi\,.\tan\gamma^1 + \frac{6\,.\,Z - \eta^1\,.\,(6\,.\,Z + 4\,.\,\pi\,.\tan\gamma^1)}{\eta^1}\right]$$

put

$$4\,.\,\pi\,.\tan\gamma^1 = \theta,$$

and

$$\therefore\ \frac{39{,}600\,.\,H}{\pi\,.\,\rho\,.\,D^2\,.\,V^3} = \frac{[6\,.\,Z - \theta\,.\,\eta]\,.\,[6\,.\,Z - \theta\,.\,\eta - 6\,.\,Z\,.\,\eta]}{\eta^3\,.\,Z^2}$$

Now call the left-hand side of the equation Σ, then :

$$\Sigma = \frac{[6\,.\,Z - \theta\,.\,\eta]\,.\,[6\,.\,Z - \theta\,.\,\eta - 6\,.\,Z\,.\,\eta]}{\eta^3\,.\,Z^2}$$

Hence, for any given value of Σ, there will be some value of Z for which η is a maximum. And thus the best value of Z to employ in any given case can be found from this equation, when Σ is known, by "trial and error."

The value of tan γ may be taken to be 0·05, so that :

$$\theta = \frac{4\,.\,\pi}{20} = \frac{\pi}{5} = \cdot 628$$

Example.—Let H = 130, V = 160, n = 20, and suppose we wish to find the value of D that makes η a maximum.

Hence :

$$Z = \frac{V}{n\,.\,D} = \frac{160}{20\,.\,D} = \frac{8}{D}$$

And :

$$\Sigma\,.\,D^2 = \frac{39{,}600 \times 130 \times 420}{\pi \times (160)^3} = 168\cdot 5$$

$$\therefore \frac{168\cdot 5}{D^2} = \frac{\left[\frac{48}{D} - 0\cdot 628\eta\right]\,.\left[\frac{48}{D} - 0\cdot 628\,\eta - \frac{48}{D}\,.\,\eta\right]}{\eta^3\,.\left(\frac{64}{D^2}\right)}$$

$$\therefore \frac{168\cdot 5}{D^2} = \frac{[48 - (0.628)\,.\,\eta\,.\,D]\,.\,[48 - (0\cdot 628)\,.\,\eta\,.\,D - 48\,.\,\eta]}{64\,.\,\eta^3}$$

$$\therefore 10{,}800\,.\,\eta^3 = D^2\,.\,[48 - (0\cdot 628)\,.\,\eta\,.\,D]\,.\,[48 - (0\cdot 628)\,.\,\eta\,.\,D - 48\,.\,\eta]$$

We may now form the following table :—

D	4	6	8	10	12	20	Feet.
η°/₀	80	$84\tfrac{1}{2}$	$85\tfrac{1}{2}$	$85\tfrac{1}{2}$	$84\tfrac{1}{2}$	$78\tfrac{1}{2}$	Efficiency percentage

From which it is evident that the maximum efficiency occurs when D is about 9 ft., there being, however, a large range of diameter over which the efficiency

remains high. Between such limits as 4 ft. and 20 ft. in diameter the efficiency is still round about 80 per cent. In practice a 4-ft. diameter airscrew would be quite inadmissible owing to size of body, &c., which would interfere with its action. These, and in fact any, calculations of this kind assume the propeller to be working freely. The writer has designed an airscrew of only 6½ ft. diameter for a 170 brake horse-power motor, the performance of which in flight was quite good.

Now it is evident from these formulæ that the efficiency η^1 of an airscrew, designed to have a constant slip along the blade length, is a function of two independent variables n and D. The analysis required to establish the criteria for maximum efficiency in the general case will of necessity be rather complicated and troublesome.* The formulæ may be easily applied in any given case.

Moreover, the brake horse-power equation is now in a form suitable for graphical generalisation.

If, we for example, take $\tan \gamma^1 = 0{\cdot}05$, then it is easily seen that the three variables involved in this equation are:

$$y,\ Z,\ \text{and}\ \left(\frac{H}{\rho \,.\, D^2 \,.\, V^3}\right),$$

all of which are non-dimensional. We can then very easily devise a series of graphs by which the value of y can be found when Z and

$$\frac{H}{\rho \,.\, D^2 \,.\, V^3}$$

are known. Since $y = S/V$, this fixes the slip, and the design may then be at once proceeded with.

The foregoing, therefore describes a process by which:—

1. Airscrews may be designed very easily for any conditions.
2. The best conditions to employ in any case can be found.
3. The efficiency under any conditions can be found.
4. And, finally, the method may be made the basis for a series of graphs by which the whole of the work of computation usually necessary may be avoided.†

Appendix.

In the introduction to this paper the statement was made that for a screw propeller working "statically" the value of the A^1 angles along the blade length was constant for any radius and independent of the revolutions/sec. n.

The following brief analysis contains the proof of this statement:

By definition: $A^1 = \phi - a^1$ for any radius x.

The formula connecting the momentum change with the aerodynamical computation of axial thrust is generally:

$$C\,y^1 = [2\,.\,\mu + c\,x^1]\,.\,\tan\,(A^1 - A)$$

And this may be expressed quite generally as:

$$C\,y^1 = F\,(A^1\,.\,A\,.\,X)$$

But for a 'static' test:

$$V = 0\,.\,i.e.\ A = 0$$

and

$$(1)\quad .\quad .\quad \therefore C\,y^1 = F\,(A^1\,.\,x) = F\,[\phi\,.\,a^1\,.\,x]$$

Also the aerodynamical equation connecting $C\,y^1$ with a^1, obtained experimentally from the wind-channel, is of the form:

$$(2)\quad .\quad .\quad .\quad .\quad C\,y^1 = f\,(a^1)$$

for any given section.

Hence combining (1) and (2), we find:

$$a^1 = F^1\,[\phi\,.\,x]$$

And therefore

$$A^1 = \phi - F^1\,[\phi\,.\,x]$$

Hence, since for any radius X, ϕ is constant, it follows that for any radius A^1 is constant and independent of the revolutions/sec. n when $V = 0$. This is the equivalent of the statement referred to above.

(To be continued.)

* In general there appears to be no true maximum value when n and D both vary independently. The efficiency appears to increase indefinitely.

† This point will be given in the last part of this paper. The foregoing analysis has been given at length; in the final graphical applications, the approximations introduced are outlined in a much more simple manner.

HELL GATE BRIDGE, NEW YORK.

By Frank W. Skinner, M.Am.Soc.C.E.

(Continued from page 504.)

Adjusting Backstay and Arch Trusses.

The different stages of erection that have been described required three separate adjustments of the backstay and incompleted arch trusses, each of which was a critical operation made by the special hydraulic jacks over the tops of the main piers.

All of these operations were made in accordance with previously prepared diagrams of the deflections and displacements of the incompleted trusses at different stages which took into consideration the elasticity of the material, temperature distortions, dead load, and erection stresses, giving the different positions of the panel points with reference to their geometrical positions. Four diagrams, Fig. 60, 61, 62 and 63, on page 604, were prepared, one showing the trusses when the upper backstay ties were connected and just beginning to take stress; one showing the trusses after the lower backstay ties had been removed and the backstays were jacked to full height; another showing the position at the time of erecting the last panels of lower chords, and the last showing the position when the backstays were released transforming the cantilever trusses to three-hinge arch trusses. During these movements the arch trusses were subject to considerable change of form rising about 1¾ in. at the centre and settling about 3 in. at the quarter points. While the arch trusses were being built out from panel point 11 to panel point 22 at the centre the vertical movements of panel point 11 on opposite sides of the river were 9·6 in. and 9·9 in. and the tops of the vertical posts in the backstay trusses, over the main piers moved horizontally 10·4 in. and 11·2 in. respectively, due to the extension of the backstays under increasing stress.

In order to transfer the entire load of the uncompleted arch trusses from the lower to the upper top chords of the backstay trusses and to elevate the arch trusses to the required height it was necessary to raise the backstay trusses 22½ in. over the main piers about half of which was required to release the lower backstay top chords. Partial jacking was accomplished first day to relieve lower stay from high stress and jacking completed after another panel was erected. This was only on one side. The operations were closely checked by comparing measurements on the plungers of the hydraulic jacks and on the eye-bar links in the upper chords calculating the stresses therefrom and comparing them with stresses computed from extensometer measurements made in the trusses.

The four great jacks which had a capacity of 3,000 tons each were operated at maximum pressures of 4,600 lb. per square inch and for the closing of the centre panels they were lowered 2⅜ in. for the north truss and 2⅝ in. for the south truss, corresponding almost exactly with the calculated amount of 2⅝ in. after which they were lowered 15 in. more to release the backstays.

As the semi-arch trusses were lowered to their final bearing, gradually releasing the heavy strain in the backstay trusses, the weight of the counterweight which had balanced the reaction was rapidly transferred to the foundations. A maximum of nearly 8 tons per square foot would have been imposed on the comparatively soft ground on the Long Island side but that it was somewhat reduced by the rapid removal of as much of the earth ballast as possible during the period that the jacks were being operated. Even with this precaution an average settlement of 2½ in. occurred, an amount which was within permissible limits. Had the settlement been enough larger to cause anxiety it would have been checked by the operation of eight 500-ton hydraulic jacks provided for emergency to take up the settlement, if necessary, and prevent the development of excessive strains and dangerous secondary stresses that it was feared might possibly occur in the very rigid plate girders forming portions of the backstay trusses.

The principal lowering operation was accomplished in 1¼ hours and a very slow and regular movement of the jacks was secured by the use of a special needle valve exhaust and by a very careful system of measurements, signals and communications that governed the operation.

The water from the jacks was discharged through two tandem reduction valves permitting the escape of a small quantity of water.

The men operating the jacks were kept in constant telephone communication through which all of the movements read from the jack scales were announced on six open receivers in the field and office so that in the beginning the jacks never varied more than ⅛ of an inch, seldom more than $\frac{1}{16}$ in., and later on when stresses became small the variations never exceeded a maximum of ¼ in. at all four points.

3,000-ton Jacks.

The 3,000-ton hydraulic jacks used in adjusting the backstay trusses, although believed to be the largest of their kind ever yet built, were of very simple construction that would permit of their size and capacity being materially increased without difficulty. Each jack consisted of a cast steel cylinder with walls 6½ in. thick bored to receive a hollow plunger 39 in. in diameter with walls 6 in. thick. The cylinder was reinforced by a top ring and was packed with six 1 in. by 1 in. rings of hemp held in position by a bolted ring. The cylinders were 34 in. high inside and were provided with bases 9 in. thick.

They were operated by a pump driven by compressed air in an 8-in. cylinder, operating a 1-in. water cylinder with a 12-in. stroke. The jacks were tested to a pressure of 5,000 lb. per square inch.

Extensometer Test.

In order to check the calculated stresses a system of extensometer measurements was made on the lower chord and some other members of the arch and of the backstay trusses.

A 20-in. Howard extensometer was used on which readings could be taken to the $\frac{1}{10,000}$ of an inch, a distance which, in the 20 in. observed, was assumed to correspond to a stress of 150 lb. per square inch. All readings were corrected for temperature. While the chord members were on the floats upon which they were delivered at the bridge site, six gauge lines were located inside at each end by drilling holes in the vertical legs of the angles of the top, centre and bottom horizontal webs, and zero stress readings were then taken. Afterwards readings were taken at the same points in different stages of the erection, but it was found impossible to get satisfactory reading when the sun was shining on the member, as the temperatures became very uneven, whether the member was still on the float or whether it had been erected.

These readings were delicate enough to indicate difference in the stresses of different eye-bars in the same group that were due to very minute differences in their bored lengths. They also indicated a slight degree of compression in the lower backstay top chords when the load had been transferred to the upper top chords and thus required a slight jacking up to enable the connection pins to be driven out.

Stress Measurements.

A full description and record of the stress measurements together with an analysis of them, was given in a paper by Mr. D. B. Steinman presented to the American Society of Civil Engineers and published in vol. lxxii of the proceedings. The following data relative to these stress measurements are abstracted and extracted from that paper.

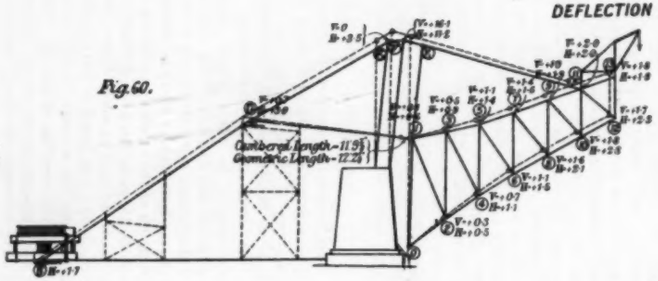
The stresses were measured in various members of the arch trusses and in the backstays in successive stages of the erection, particular attention being given to them as the critical stages of construction were reached and passed. One of the eyebars in a forward stay was found to have a stress 55 per cent. higher than the average in the group at an early stage of the erection when the stresses were low. As the stresses increased the difference decreased until the stresses were about uniform in all the bars at 20,000 lb. per square inch. The operations of the hydraulic jacks in the erection towers were checked by measurement of the stresses in both sets of stays. Stress measurements were also taken to check the diminishing stresses in the forward stays

HELL GATE BRIDGE, NEW YORK.

MR. GUSTAV LINDENTHAL, CHIEF ENGINEER.

DEFLECTION DIAGRAM FOR PRINCIPAL ERECTION STAGES.

Fig.60.



UPPER BACK-STAY TIE CONNECTED AND JUST BEGINNING TO TAKE STRESS.

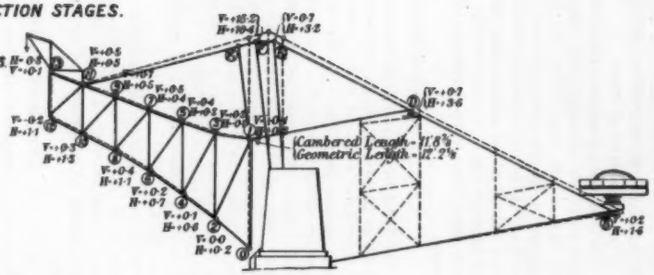
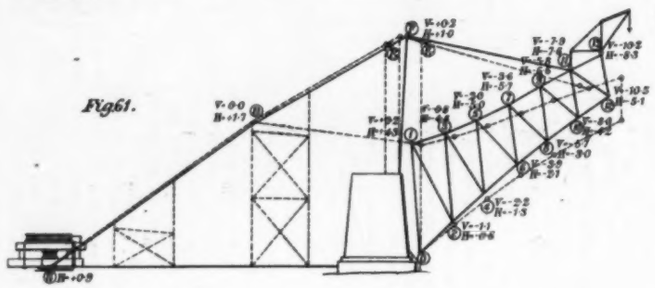
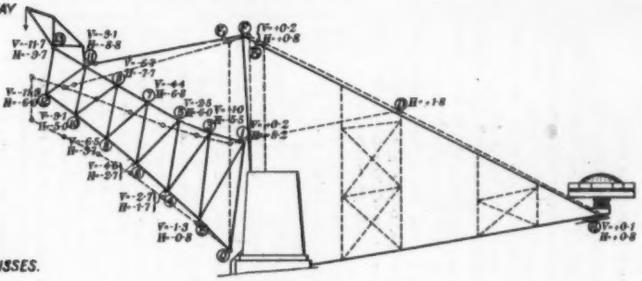


Fig.61.

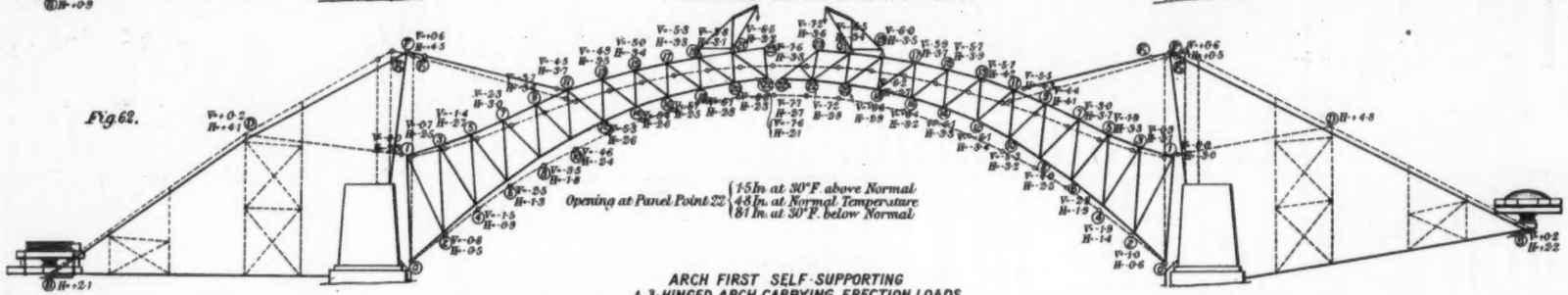


AFTER DISCONNECTING LOWER BACK-STAY TIE AND JACKING F TO FULL HEIGHT.



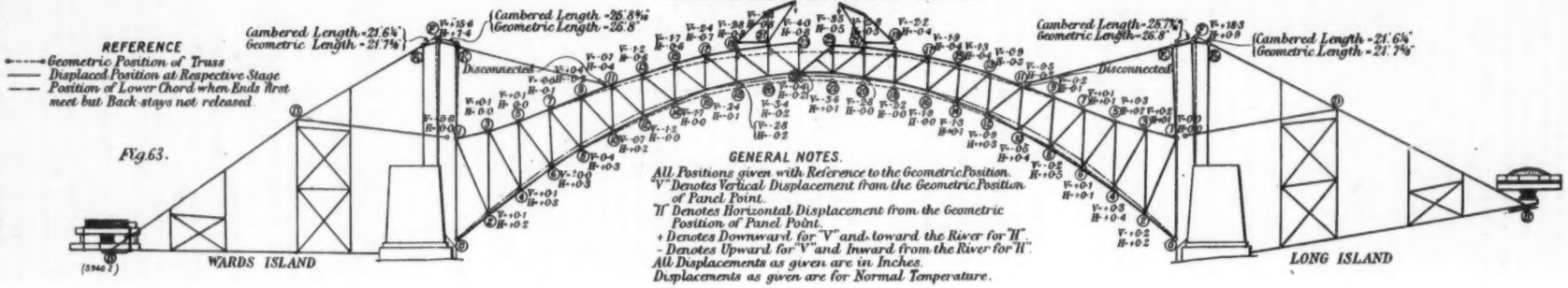
IMMEDIATELY BEFORE LOWERING TRUSSES.

Fig.62.



ARCH FIRST SELF-SUPPORTING
A 3-HINGED ARCH CARRYING ERECTION LOADS.

Fig.63.



GENERAL NOTES.

All Positions given with Reference to the Geometric Position.
"V" Denotes Vertical Displacement from the Geometric Position of Panel Point.
"H" Denotes Horizontal Displacement from the Geometric Position of Panel Point.
+ Denotes Downward for "V" and toward the River for "H".
− Denotes Upward for "V" and Inward from the River for "H".
All Displacements as given are in Inches.
Displacements as given are for Normal Temperature.

when the semi-arches were lowered for the connection in the centre panel.

The final object of the stress measurements was to provide a comparison between the calculated and the actual secondary stresses in the permanent structure.

The schedule of stress measurement provided for more than 3,000 readings taken at 14 different stages of the erection on the arch truss itself, besides special measurements in the backstays and eye-bar connection links. As the measurements were taken in the interior of the great box-like sections of the lower chords considerable delay and difficulty were experienced in crawling through the numerous diaphrams that stiffen these members, and there was not time to take all of the intended measurements, therefore in some cases measurements were omitted in alternate members.

Among the conclusions arrived at by Mr. Steinman from a study of these measurements are the following:

The average difference of 5 per cent. between calculated and measured primary stresses is due principally to variations in the loadings and cross-sections from the values assumed.

The extreme variation of fibre stress from the average stress was found to range from about 1,600 lb. to 2,500 lb. per square inch in the lowest and highest primary stresses respectively. The bulk of this variation was considered to be due to various irregularities and inaccuracies. In order to obtain the limiting safe working stress for bridge members under average conditions it appears that about 25 per cent. plus 4,000 lb. per square inch should be deducted from the mimimum elastic limit of the material.

During erection the secondary stresses due to bending in the plane of the truss had an average value of 1,050 lb. per square inch calculated, and only 700 lb. per square inch measured. Except for the smallest secondary stresses the measured values were consistently lower than the calculated values, and for the highest percentages they were only a small friction of the latter. The conclusion is that there is an automatic readjustment of strains within a structure tending to relieve the secondary stresses so that their actual value will generally be lower than the calculated value.

In the early erection stages the three-faced bottom chord joints acted as hinges, permitting rotation that relieved the secondary stresses. In succeeding stages the rotation was restricted and eventually, under less compression, rotation again occurred.

Measurement across the splices before and after riveting showed a complete closing of the joints during this operation. This demonstrated the transfer of initial stress from the spliced material to the butt joint.

The curve of calculated secondary stresses shows a great reduction in passing from the cantilever to the three-hinge arch construction and in the final stage the extreme fibre stresses as measured indicating that the combination of primary and secondary stresses agreed remarkably well with their calculated values.

Eliminating Crown Hinge.

After the complete erection of the last members in the centre panels of the arch trusses the transformation from a three-hinge to a two-hinge arch was accomplished by riveting the connections at the previously loose west ends of the top chords and diagonal members in those panels. The connection plate was erected, riveted to one member, and blank at the opposite end. Therefore it was necessary to drill all the rivet holes in them to correspond with the open field rivet holes in the members to which they were connected.

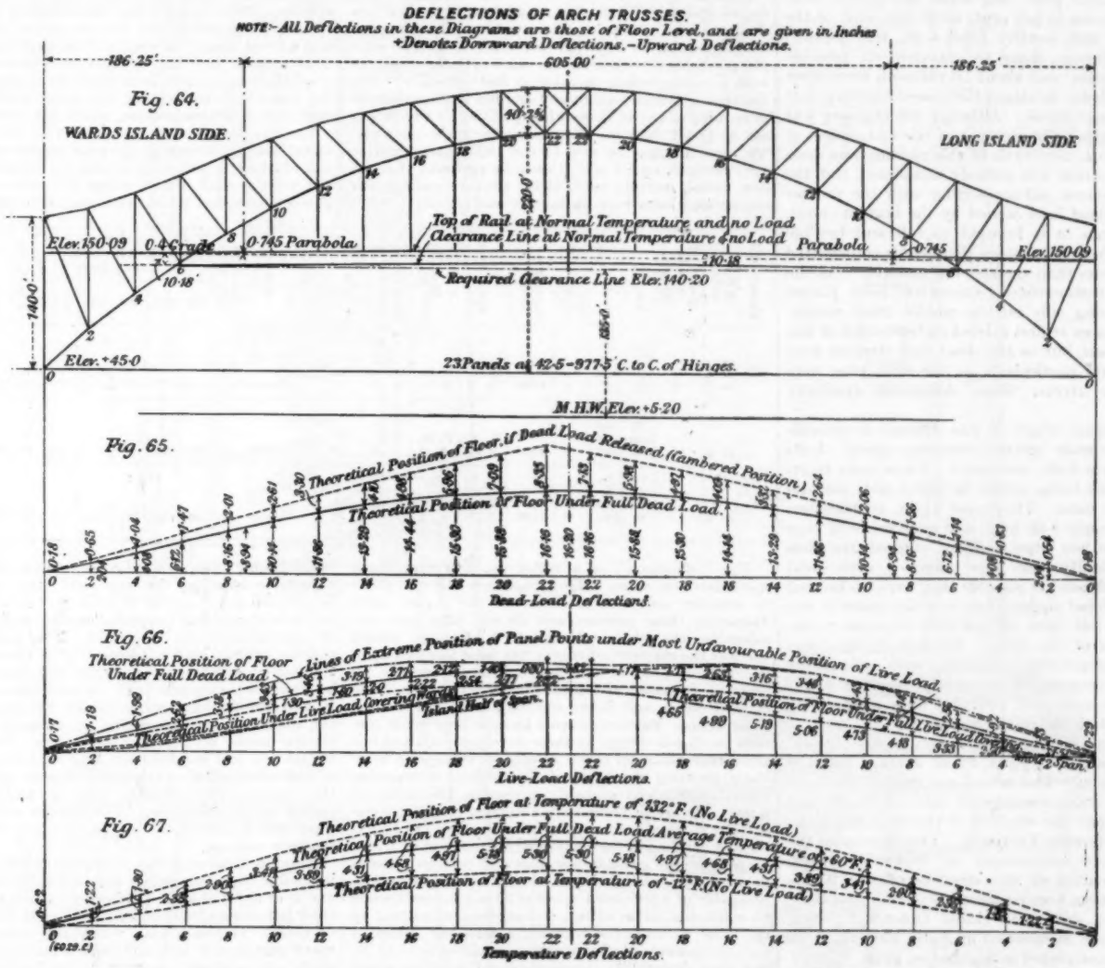
Although no elasticity deformations took place in the arch trusses during this operation and the connections were to be made without initial stress at normal temperature, the drilling and riveting required several days during which considerable changes of temperature had to be provided for, and in order to prevent displacement of the connection after the drilling was commenced the loose end of the top chords were held in position by screw-end horizontal tension rods 8 in. in diameter installed inside each top chord and having at each end double nuts taking bearing on vertical transverse diaphragms in the adjacent chord members so that the rods served as a tension and compression splice across the open chord joints.

Under favourable conditions when the temperature was practically normal and uniform over the whole structure the nuts on the rods were tightened to develop a slight initial stress and the rods were left in this condition with ample strength to take up all temperature stresses that might develop during the riveting of the connections.

Field Riveting.

All work at the connections, assembling, reaming, fitting and riveting, was done by men in steel cages handled by the derrick booms on the traveller and on the suspended erection bridge already mentioned. This feature of the work, combined with very careful regulations and standard safety appliances provided by the bridge company, were so successful that no casualties occurred from men falling from these platforms, and none were due to plant accidents.

The erection of the bridge involved the driving of


DEFLECTIONS OF ARCH TRUSSES.
NOTE:-All Deflections in these Diagrams are those of Floor Level, and are given in Inches
+Denotes Downward Deflections.,-Upward Deflections.
186·25'
605·00'
186·25'
Fig. 64.
WARDS ISLAND SIDE.
LONG ISLAND SIDE
Elev. 150·09
0·4 Cycle
0·745 Parabola
Top of Rail at Normal Temperature and no Load.
Clearance Line at Normal Temperature & no Load
Parabola
0·745
Elev. 150·09
10·18'
Required Clearance Line Elev. 140·20
140·0'
Elev. +45·0
23 Panels at 42·5=977·5' C. to C. of Hinges.
M.H.W. Elev. +5·20
Fig. 65.
Theoretical Position of Floor if Dead Load Released (Cambered Position.)
Theoretical Position of Floor Under Full Dead Load.
Dead-Load Deflections.
Fig. 66.
Theoretical Position of Floor Under Full Dead Load
Lines of Extreme Position of Panel Points under Most Unfavourable Position of Live Load.
Theoretical Position Under Live Load Covering Whole Island Half of Span.
Theoretical Position of Floor Under Full Live Load
Live-Load Deflections.
Fig. 67.
Theoretical Position of Floor at Temperature of 132°F. (No Live Load.)
Theoretical Position of Floor Under Full Dead Load Average Temperature of 60°F.
Theoretical Position of Floor at Temperature of -12°F. (No Live Load)
Temperature Deflections.

about 17 field rivets per ton of steelwork, and these included 202,404 1¼-in. rivets with grips up to 10 in. in the arch trusses and 131,556 1-in. rivets in the floor system and bracing. These large rivets were machine finished, of special design, and very accurately made, as previously described. As the average number driven in 8 hours by one gang was 135 1¼-in. rivets, and about 6 per cent. or 7 per cent. had to be cut out and redriven, it was estimated that the labour cost of driving on the first 40,000 rivets was about 25 cents each. The rivets were driven by a maximum force of 25 four-man gangs, and the largest number of rivets driven by one gang in one day was 356.

All truss connections were temporarily made with bolts and drift pins, and when the pieces were assembled, from 25 per cent. to 60 per cent. of the rivet holes were usually filled with drift pins to provide sufficient shear to transmit all possible erection stresses, and about 50 per cent. were filled with rough bolts to clamp the pieces together, but not to transmit stress. Although the engineer was willing to permit the riveting of the end panels of the top chords, very little of this riveting was done until the erection was entirely completed, and the arch had become self-supporting with the greater part of the dead load carried by the bottom chord, and the joints in it brought to full and forcible contact so that the sections themselves transmitted a greater stress than the splicing material. As the ends of the bottom chord sections had been planed to take bearing only on the middle third, wedge-shape clearances at first existed on both sides of this bearing section, but as the dead load stresses were developed and particularly as the drift pins were replaced by rivets, these clearances gradually diminished.

In some cases where it was difficult to provide for the maximum erection stresses, special bolts called drift-pin bolts were used. These were tight-fitting tapered bolts, driven in like a drift pin and secured with nuts. They were 1¼ in. in diameter, with grips nearly 1 ft. long, and were made of very hard high-carbon steel. They entered the hole without difficulty, but were removed with great difficulty. Whenever possible they were backed out with heavy hand sledges, but in many cases it was necessary to cut them off and drill them out to the full diameter of the holes. All field riveting was done by pneumatic hammers with pneumatic buckers-up operated by air at a pressure of about 120 lb. per square inch, provided by a compressing machine at each end of the bridge.

The erection of the superstructure was accomplished in about two years, by an average force of about 250 men. The actual erection of the arch span proper was accomplished between March and November, and the erection of the floor was completed the following February. The erection of the backstays was commenced in September, 1914. The preliminaries of the erection of the Wards Island backstays were commenced in January, 1915, and the arch span was closed October 1, 1915. Backstays were dismantled in April, 1916, and the riveting was completed in September, 1916.

The computed deflections of the finished span under different load and temperature conditions, and the cambre ordinates, are shown on the diagrams, Figs. 64 to 67, on page 605.

(To be continued.)

WOLSELEY CARS AT OLYMPIA.

Messrs. Wolseley Motors, Limited, of Birmingham, are now manufacturing three different chassis: 10-h.p. (four-cylinder), 15-h.p. (four-cylinder), and 20-h.p. (six-cylinder), examples of each of which are on view at the Olympia Exhibition. The principal dimensions of the three models are given in the table annexed.

The policy of the company is to produce mainly completed cars fitted with bodies and equipped with every really necessary accessory. The new models comprise a very complete range of motor carriages for every purpose, from the handy runabout to the six-seater town carriage. The Wolseley Company have acquired the Electric and Ordnance Accessories Company, Limited, together with their plant and buildings, and the 10-h.p. model will be produced in this factory. The other two models—the 15 h.p. and 20 h.p. will be built at Adderley Park. During the war, motor-car production in these factories completely ceased, and other more important work was carried on. Large additions were made, and the workshop area was considerably increased. Since the armistice, further large additional buildings have been put in hand and are now in course of construction, so that when the whole are completed the two factories making the three models will have a capacity for producing 20,000 complete cars per annum.

As was to be expected, the designs have been very materially modified, and full advantage has been taken of the advance made in engine construction, alloy steels and other materials being used. Wolseley cars have always been noted for extreme smoothness in running of both engine and vehicle. In order to attain this very desirable feature, they have heretofore employed a somewhat small valve area, thereby limiting the maximum power developed by the engine at high engine speeds. The most striking feature in their new designs is the opening up of valve areas of the engine, and increasing by some 20 per cent. to 25 per cent., the power developed from the same cylinder capacities with a corresponding increase in fuel efficiency. This has been attained without any sacrifice in the sweetness of running or any of those other qualities for which they are so justly famous. To those who know their pre-war productions, the step to the 1920 chassis will be very marked, and it will at once be apparent that the new models embody much of the advance made in our engineering knowledge during the war period.

Maker's H.P.	R.H.C. Rating.	Weight of Chassis Empty.	Engine. Bore.	Stroke.	No. of Cyls.	Normal Revs.	Wheel Base.	Track.	Body Space. Dash to End of Frame.	Width of Frame.	No. of Gears.	Drive.	Standard Axle Ratio.	Approximate Road Speed (M.P.H.) at Normal Engine Revs. 1st	2nd.	3rd.	4th.	Reverse.	Approx. Road Wheel Dia.	Tyres, All Wheels	Turning Circle.
10	10·5	0	in. 2⅝ mm. 65	in. 3¾ mm. 95	4	1700	ft. in. 8 3	ft. in. 3 10	ft. in. 5 5	in. 27	3	Worm	7/33	8½	17	26	—	11	in. 28	710 × 90	ft. 34
	15·6	16	in. 3½ mm. 80	in. 5½ mm. 130	4	1700	ft. in. 9 10	ft. in. 4 4	ft. in. 7 9	in. 34	3	Worm	7/33	10	20	34	—	12½	in. 32	815 × 105	ft. 36
20	23·5	—	in. 3½ mm. 80	in. 5½ mm. 130	6	1400	ft. in. 11 5	ft. in. 4 6	ft. in. 8 8	in. 32	4	Worm	9/37	8	16½	24	32½	8	in. 32	820 × 135	—

The "efficiency" of a motor car is a very much misunderstood term. Many engineers are too prone to consider only the efficiency of the engine when discussing these matters, and do not take into consideration the whole vehicle. It is true that during the war the majority of energy has been focussed upon the improvement of internal-combustion engines for aviation purposes, and great strides have been made in their design and in the materials employed in their construction. Material advance has also been made possible in chassis design by these developments, and full advantage has been taken of the advantages of alloy steels, resulting in a lighter design without encroaching upon, and indeed probably increasing, the factor of safety. The term "efficiency" applied to a motor car is really its passenger carrying efficiency and can be expressed in terms of fuel consumed in transport of a passenger per mile, per mile per hour with comfort; that is to say, if a car can travel at an average speed of 30 m.p.h., is capable of a maximum speed of 50 m.p.h., and travels 15 miles on a gallon of fuel, and another car putting up the same performance travels 25 miles per gallon of fuel, the measure of efficiency then would be as 15 to 25, and their desirability (assuming equal comfort) would depend upon the capital and maintenance cost of the vehicles. In comparing the relative merits of cars, this should be borne in mind, and car performance on the road only should be taken into account, and not merely the capacity of the engine to develop a maximum of power per unit of cylinder capacity. A careful study of the new Wolseley models discloses that this point has been thoroughly appreciated. The engine efficiencies have been put up, and the chassis weights have been materially reduced by the employment of the higher grade materials now obtainable.

We illustrate in this issue the 10-h.p. and 15-h.p. four-cylinder models, and propose next week to deal fully with the 20-h.p. six-cylinder. Great care has been given to the design of body work, which is of very pleasing appearance. The design is such that the various pieces of wood and metal from which they are built up are arranged for production in quantities as separate entities, so that the same method of manufacture can be applied to bodies as is usual for the mechanical parts of the car. They are all treated as separate components and jigs and templates and special cutting machinery, and tools, are provided for their manufacture. The panels and other sheet metal portions will be pressed to shape in large power presses, so that the minimum manual labour is employed for the construction. The company are manufacturing bodywork as follows: For the 10-h.p. chassis, two-seater, three-seater and two-seater *coupé* bodies; for the 15-h.p. chassis, touring and saloon bodies; and for the 20-h.p. chassis, touring, landaulette, limousine and four-seater *coupé* with folding head, bodies.

The 10-h.p. chassis, Figs. 1 and 2, on Plate XXXIII, has been developed from the "Stellite" design, and follows it closely in general arrangement. The engine, Figs. 3 and 4, on the same Plate, has been completely redesigned. The cylinder dimensions are $2\frac{5}{16}$ in. (65 mm.) bore, 3¾ in. (95 mm.) stroke, and it develops 20 h.p. The wheel base has been lengthened, and electric lighting and starting equipment added. The camshaft has been placed upon the top of the engine, and is driven by bevel gearing from a vertical shaft. A dynamo is mounted on the near side of the engine, and behind it a "Blic" distributor, which is driven by a universal joint mounted on an extension of its spindle. Directly over the crankshaft is mounted a spindle which carries the fan belt pulley on one side, and a bevel pinion driving vertical shaft on the other. This spindle and the dynamo are driven from the crankshaft by a continuous silent chain wrapped round the three sprocket wheels, the whole making a very neat, compact arrangement, which has been patented.

The crankshaft is mounted in two die-cast white metal bearings housed in the main engine case, the top half of which is cast integral with the cylinders. Upon the vertical shaft which drives the camshaft, a gear pump is mounted which feeds the oil to the camshaft bearing and cam, and also maintains the level in troughs lubricating the big ends. An ample duct is provided to return the oil from the top of the engine to the base, which is a separate casting, and can readily be disconnected for inspection. The cooling is by thermo syphon and is assisted by a three-blade fan running on ball bearings mounted on a bracket carried up from the timing gear case. An eccentric adjustment is provided for the tension of the flat fan belt. On the other side of the engine is mounted a "Blic" electric motor for starting the engine. The flywheel is cast-iron and has bolted to it a mild steel gear ring in which the pinion on the motor engages when starting the engine. The cylinder head is detachable and carries all the valve gear. The exhaust and induction pipes which carries the Zenith carburettor are both separate castings.

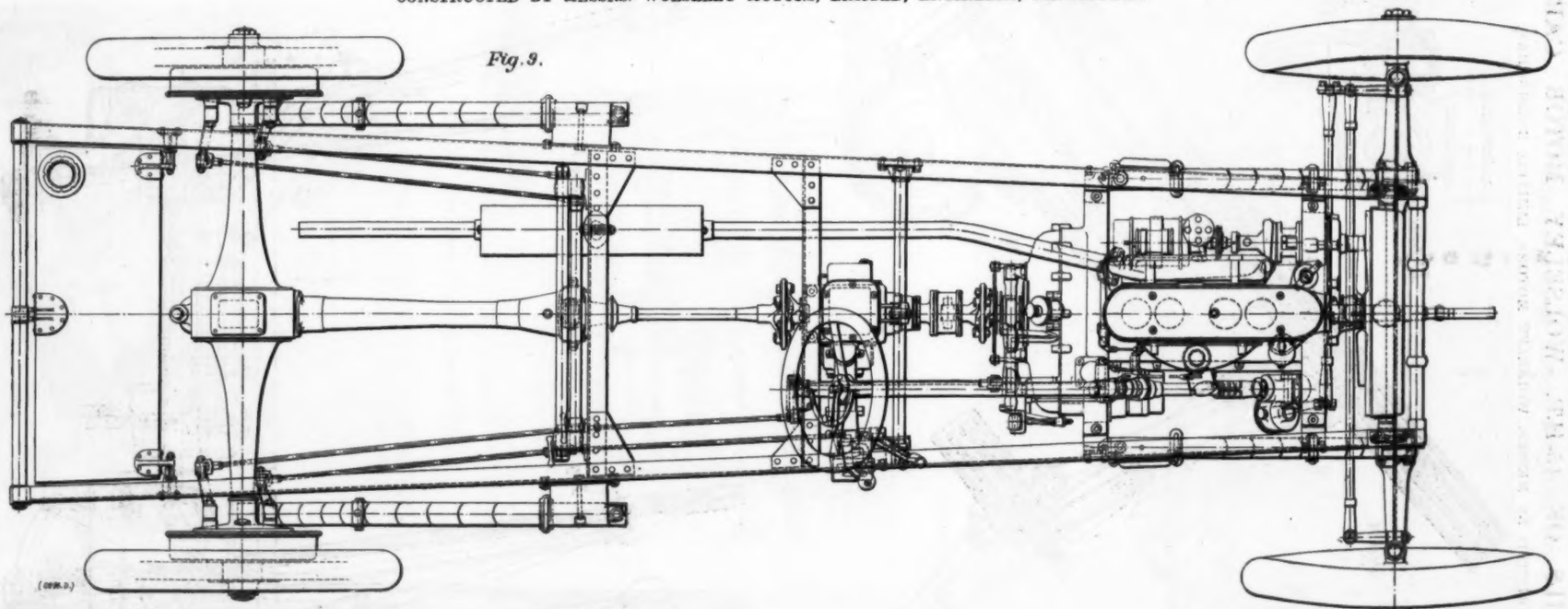
The clutch, shown in Fig. 5, on Plate XXXIII, is of the multi-disc type, completely enclosed and running in oil, and is of the well-known Wolseley pattern made under their patents and which they have used for a number of years. The back axle, which also carries a three-speed gear-box, is driven through a universally-jointed shaft with a fabric-type joint at the leading end, and slipper-box type at the back end. The final drive is by a worm wheel which surrounds the straight-tooth differential. The back axle, Fig. 8, on Plate XXXIII, is built up of three steel castings, the centre, carrying the housing of the gear-box and worm wheel and two tubular portions, on the outer ends of which are carried the brakes, and the outer Timken bearing for the road wheel. The pedal and hand brake operate upon a single drum bolted to the hub, and are of the internal expanding cam-operated type. The design is quite novel. The two fulcrum pins are set at 90 deg., and the webs of the shoes are made to pass one another. The braking surface of each of the four shoes covers about 80 deg. of the circumference and extends across the full width of the drum, so that each brake has the benefit of the full wearing surface on the drum. The torque member, Fig. 6, is a steel casting bolted to the front of the gear-box, and has a spherical end which fits into a link machined to fit the sphere which hangs from a tubular cross-member upon which it is free to swing. The car is propelled through the springs.

The gear change is of the quadrant type, the selector rods being hinged in line with the centre of the sphere on the torque member. The gears slide upon a castellated shaft which is integral with the driving worm. All shafts and road wheels run on Timken roller bearings of ample dimensions. The springs are of

15-H.P. WOLSELEY MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. WOLSELEY MOTORS, LIMITED, ENGINEERS, BIRMINGHAM.

Fig. 9.

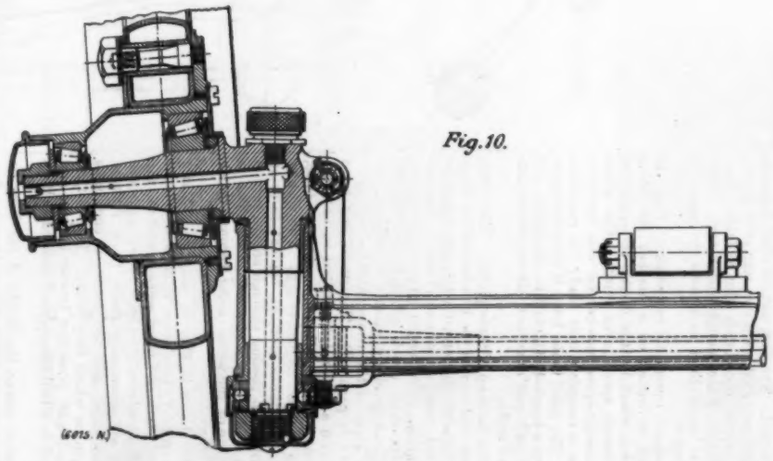


the cantilever type directly bolted to the axles, and the pressed channel steel frame. The front springs are provided with a patented safety device which consists of a spring steel plate about 6 in. long, shown on the front spring in Fig. 1. It is bolted to the axle by the same bolts as the bottom spring plate, and has an eye formed at the other end. This is attached by a pair of shackle plates to a similar eye turned on the end of the fourth plate. If the bottom spring plate which normally attaches the axle to the frame should break, this plate and link keeps the axle attached to the car and prevents such a happening, resulting in a serious accident.

The 15-h.p. car is entirely a new design. Although it is not described as a fast car, it is really very speedy, and readily can attain a speed of 50 m.p.h. The springing is similar to the 10 h.p., and is extremely well balanced, so that it is possible to drive the car at high speeds over really very bad road surfaces. The suspension and steering are excellent, so that the car "holds" the road in a very satisfactory manner. The engine provides very ample power, and the acceleration is particularly good. Indeed, the whole design is very pleasing. The chassis shown in Fig. 9, annexed, and Fig. 17, on page 609, has a very clean appearance. The frame is pressed steel channel section, and is swept up in the usual manner over the rear axle. The side members are straight from end to end and not bent inwards at the dashboard, but are brought closer together at the front end to provide the necessary clearance for the road wheels when steering.

The petrol tank is carried on three points at the back

Fig. 10.



end, and the fuel is fed to the carburettor by vacuum feed. The honeycomb radiator is carried on trunnions fastened to the front end of the frame at the bottom, secured at the top by a link to the top of the engine. A pressed steel channel section cross-member attached by strong gusset plates to the flanges spans the main frame at the point of attachment of the rear springs, and takes the tortional strain applied to the frame at this point by the rear spring brackets.

The engine is of the four-cylinder type, 5½ in. stroke, 3½ in. bore, fitted with overhead camshaft and valve gear, and aluminium pistons, very similar in design and construction to the 10 h.p. The crankshaft is carried in three white metal die-cast bearings in a cast aluminium crank-case. The connecting rods are of H-section and the gudgeon pin is fixed to the little end. It works in phosphor bronze bushes in the piston bosses. The big end is lined with white metal run direct into the rod and cap. The cooling water is circulated by a centrifugal pump, the spindle of which is extended and drives a lighting and ignition set specially designed for the car by the Blic Company. The induction coil is mounted upon the dynamo, and the distributor is mounted on a vertical spindle carried on the machine driven through screw gears from the armature spindle. This unit, as in the 10 h.p., is driven by a continuous silent chain wrapped round three chain wheels. The carburettor is of special design. It has two jets, which are varied in size by the position of a taper needle; there is also a special aperture to provide petrol for starting. The size of one jet is controlled by the suction of the engine, and that of the other by the position of the throttle. This carburettor is also employed on the 20 h.p. and will be dealt with fully in our next issue. The engine is shown in Fig. 19, on page 609.

The bottom end of the steering column is carried by a horizontal hinge bolted to the front engine arm. The back end is carried by a bracket rising from the rear engine arm, which also carries the throttle and ignition control levers. The throttle and ignition control are carried by concentric shafts down the

centre of the steering column, and operate the link-work through quick-thread nuts, as has been customary in all previous Wolseley models. The steering worm is of mild steel carbonised and is mounted on Timken roller bearings. It engages with a soft carbon steel worm wheel of ample proportions, which is in one piece with its spindle. The teeth are carried round the complete circle so that those engaging with the worm may be changed by altering the position of the steering arm by moving its position on the castellations. This arrangement provides a mechanism which is very free and easy to operate, and which can be readily maintained free from backlash. Details of the steering column and gear are given in Figs. 11 to 14, annexed.

A "Blic" starting motor is mounted on the rear engine arm on the off side; this engages with a steel toothed segment bolted to the flywheel for starting the engine. The clutch is of the Wolseley patent enclosed multi-disc type, and is of the same design as has given such satisfaction on previous Wolseley models. A very effective clutch stop is provided by a spring steel plate mounted on studs on the flywheel cover, which has a circular fibre ring which comes in contact with the driven member of the clutch when the pedal is completely depressed. The gear-box has three forward speeds and a reverse, and is mounted as a separate unit upon two cross-members in the frame. The gears are made in 5 per cent. nickel steel, and the shafts of carbon steel. All are carbonised, hardened and ground. The first motion shaft is driven by a clutch shaft provided with two universal joints. The front end nearest the clutch joint is fabric type, and the rear end is of the plunger block type, which provides for the longitudinal movement necessary to withdraw the clutch.

The change-speed operating mechanism, Figs. 15 and 16, annexed, is carried on a bracket projecting from the gear-box, which in turn carries the quadrant in which the change speed lever works. The whole gear-box and change-speed mechanism can therefore be assembled as a complete unit ready for mounting in the chassis. The hand brake lever is mounted upon a stud carried on a bracket attached to the frame, and has the detent pall and quadrant carried below the frame and out of sight.

The back axle is built up of three pieces. The centre is cast aluminium and carries the housing of the worm wheel and two tubular portions, on the outer ends of which are carried the brakes and Timken bearings for the road wheels. The torque member is circular and surrounds the shaft which drives the worm, and has a spherical end precisely similar to that on the 10-h.p. model. Views of the arrangement are given in Figs. 20 and 21, on page 609. The pedal and hand brake operate upon a single drum bolted to the hub, and are of the internal expanding cam-operated type, precisely similar to those on the 10 h.p. The springs are attached to an extension of the bracket carrying the brake gear by a pin passing through an eye turned on the bottom leaf. An ample inspection door is provided on the top of the worm casing, through which lubricant is introduced.

The front axle, shown in Fig. 10, on page 607, is a stamping made from Vickers' axle steel, heat-treated and oil-tempered. It is of I-beam section, and the top flange is broadened out locally to form the spring seats. The stub axles are stampings made from Vickers' axle steel oil-tempered, and are made in one piece with the pivot pin on which they hinge. The vertical bearings are lined with phosphor bronze bushes, and the load is carried on a ball thrust, well encased to keep out the dirt.

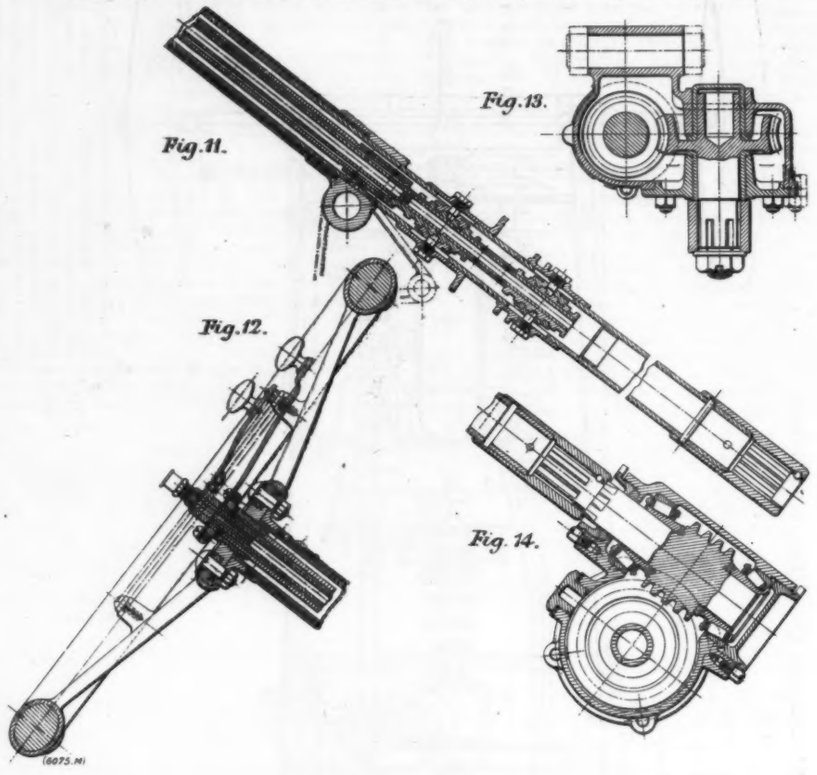
This construction places the whole of the boss on which the steering wheels hinge below their centre, and thus admits of the employment of an axle which is straight from end to end, and not dipped in the centre, as usual, to clear the starting handle. The steering tie rod is connected to the steering arms by jaw joints, and is carried behind the axle. The road wheels are of the Sankey pattern, run on Timken bearings, and are attached to the hub by five studs. The great feature of both the cars we have described is their excellent springing. The comfort with which they can be driven at a good speed on really bad roads is quite remarkable. This is no doubt attributable to the correct application of cantilever springs and to the very light unsprung weight.

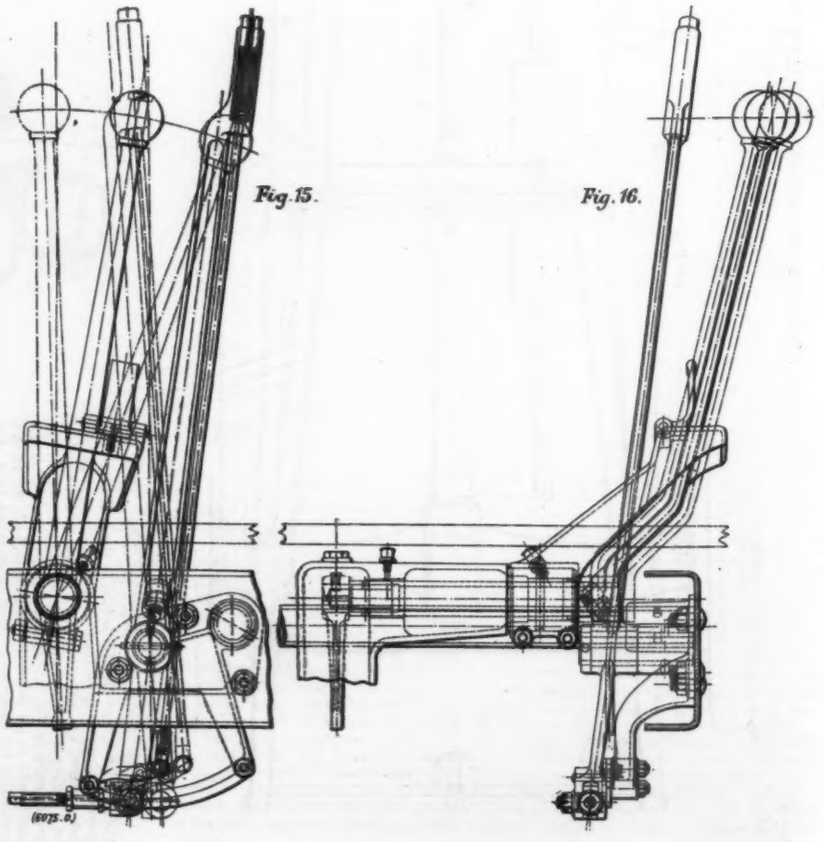
We were particularly impressed with these points when we tried these cars. The acceleration and steering are extremely good and, coupled with the light weight of 9 cwt. for the 10-h.p. chassis, and 16 cwt. for the 15-h.p. chassis, engender the feeling of speed and security which it is so pleasant to experience.

A careful examination of the chassis will show that great attention has been paid to the mechanical details, and the few joints which are not automatically lubricated have their lubricators placed in convenient positions so that there is no excuse for their not receiving proper attention.

DETAILS OF 15-H.P. WOLSELEY MOTOR CAR.

CONSTRUCTED BY MESSRS. WOLSELEY MOTORS, LIMITED, BIRMINGHAM.





15-H.P. WOLSELEY MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. WOLSELEY MOTORS, LIMITED, ENGINEERS, BIRMINGHAM.

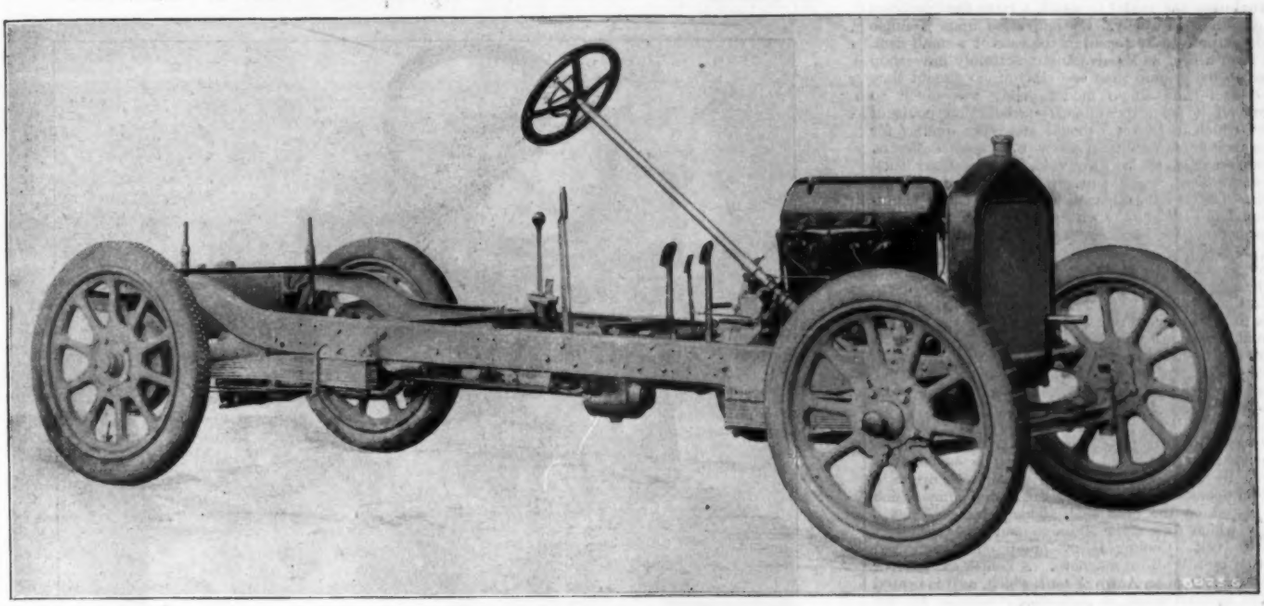


FIG. 17. GENERAL VIEW OF CHASSIS.

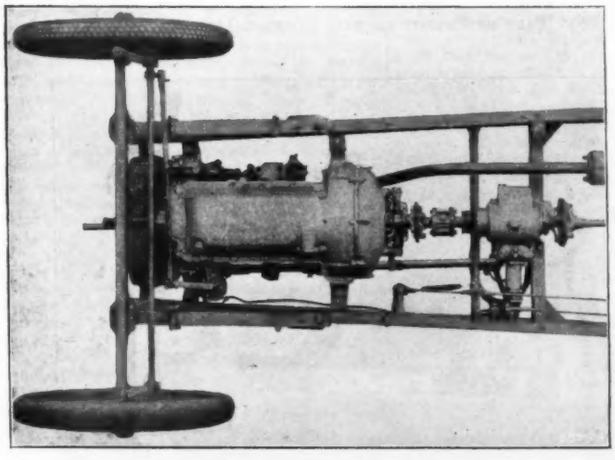


FIG. 18. INVERTED PLAN OF FRONT END.

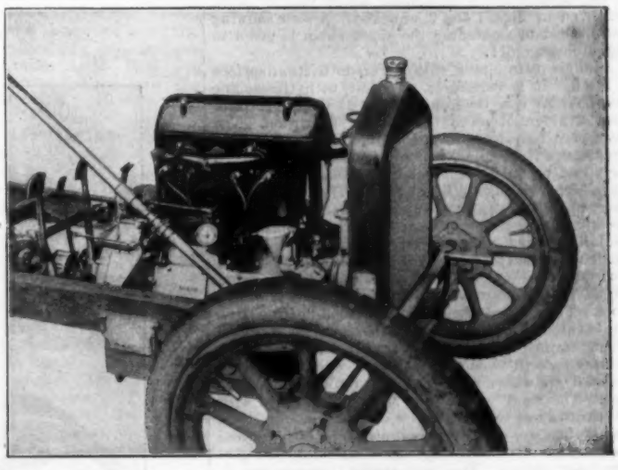


FIG. 19. VIEW OF FRONT END, SHOWING ENGINE.

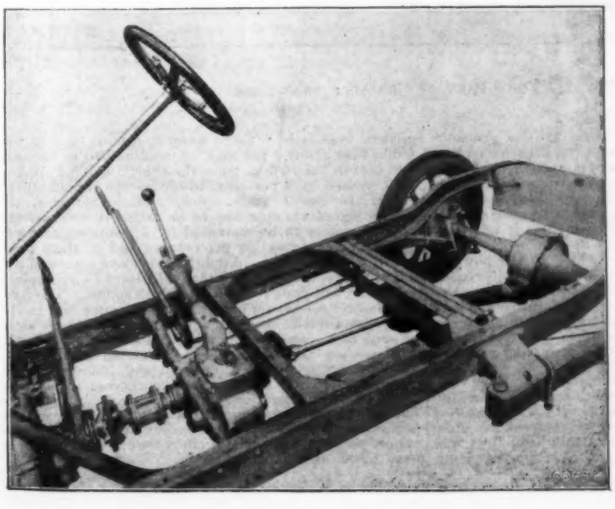


FIG. 20. REAR OF CHASSIS, SHOWING TRANSMISSION.

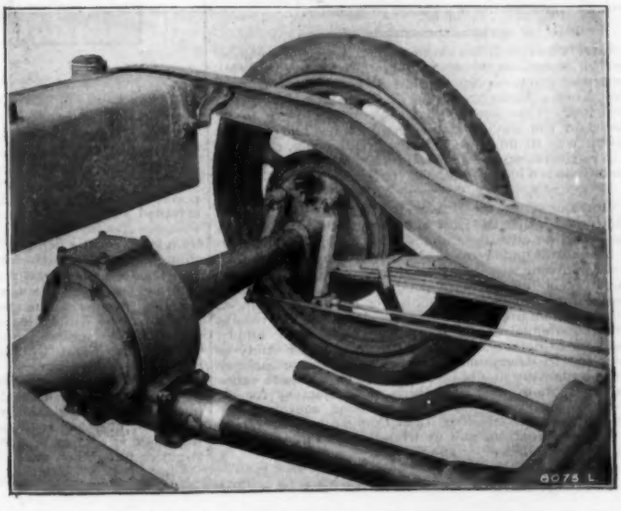


FIG. 21. THE BACK AXLE, SHOWING SUSPENSION.

20-H.P. AUSTIN MOTOR CAR AT OLYMPIA.

The car which is shown at Olympia by the Austin Motor Company, Limited, of Longbridge Works, Northfield, Birmingham, is specially interesting as representing the model to which a large firm proposes to devote itself solely. Concentration upon a single model is practically forced in the case of a small firm, but such a firm as Messrs. Austin certainly have shop room to build more than one class of car should they so desire. The single model policy has much to commend it from the quantity production point of view, which in the end should mean the quality for price point of view, and as a consequence Messrs. Austin's car is, as we have said, of more than usual interest. The projected output of the car is 150 per week. The standard chassis which is being manufactured is fitted either with a touring, landaulette or *coupe* body. The car is essentially intended for private use, and simplicity of design has been aimed at throughout.

The car, which is known as the "Austin Twenty," has a wheel base of 10 ft. 9 in. and a track of 4 ft. 8 in. It is fitted with 820 mm. by 120 mm. tyres, and the ground clearance is 9 in. The engine has four cylinders, 3½ in. diameter by 5 in. stroke, giving an R.A.C. rating of 22·4 h.p. At 2,000 r.p.m. it is capable of an output of 45 h.p. The engine is of monobloc form with detachable head of L shape, and has aluminium pistons. Lubrication is by a gear-wheel pump, forcing oil to all bearings through the hollow crankshaft, which is supported by five main bearings. The camshaft is driven by a broad silent chain which also drives a spindle operating the magneto and water pump which are placed on the near side. This spindle carries a pulley which drives the dynamo and fan through a Whittle belt. Cooling is by pump circulation and ignition by a Watford magneto. A Zenith carburettor is fitted fed from an Autovac tank which, as it is heated by the exhaust gases, is particularly suitable for use with benzol. The radiator is carried in, and is protected from damage by a frame, to which it is not connected. Two views of the engine, in which some of the arrangements mentioned above can be seen, are given in Figs. 1 and 2, annexed. A view showing the method of tightening the silent chain is given in Fig. 4 on page 611.

A single-plate clutch with a Ferodo friction surface is fitted. It is carried in one unit with the engine gear-box, as can be seen in Fig. 2. This complete unit is mounted on a three-point suspension. The gears give four forward speeds and one reverse, the direct-drive top speed being calculated as giving a car speed of 30 miles an hour. Actually, of course, much higher speeds can be attained. The change-speed lever, operating through a gate quadrant, is mounted directly over the gear-box. The hand-brake is similarly placed. This arrangement gives a simple construction and makes the driver's seat accessible from both sides of the car. The hand-brake drum is mounted behind the gear-box and is acted on by Ferodo-lined shoes. Final transmission to the semi-floating rear axle is through helical bevel gear mounted on Hoffman roller bearings and having ball thrusts. Detachable artillery-pattern wheels are fitted, and the pedal-operated rear wheel brakes are of the internal expanding type. The front wheels run on roller bearings with ball thrusts and the rear wheels on ball bearings. The road springs are of the semi-elliptic type and the rear ones, which are underslung, are 5 ft. long, and give very easy riding. The rear spring arrangement is shown in Fig. 3, on page 611. A C.A.V. electric lighting and starting set is fitted as a standard, and the petrol storage has a capacity of 16 gallons. The average consumption is a gallon to 20 miles.

Shipping from Norway to America.—A new regular service is announced from Bergen, Norway, to South American ports, *via* New York, says the *Marine Journal*, New York. Three steamers, of 5,300 tons, 6,750 tons and 9,600 tons deadweight, respectively, were to be placed in the service about October 1. The premier sailing was to be by the Thorvald Halvorsen, equipped with refrigerating space, of 500 tons capacity and accommodations for 100 first-class passengers

---

The Location of Flaws in Steel.—We read in *The Iron Age* that the Bureau of Standards, Washington, has issued an advance announcement of the publication of a scientific paper by R. L. Sanford and William B. Kouwenhoven, on "The Location of Flaws in Rifle Barrel Steel by Magnetic Analysis." By means of a special apparatus a large number of bars were explored for magnetic uniformity along their length. The results obtained demonstrated that the method is amply sensitive to detect and locate flaws. Further study is necessary to determine to what degree the sensitivity of the apparatus should be reduced in order not to cause the rejection of material which is satisfactory for all practical purposes. The work is being continued by the Winchester Repeating Arms Company, co-operating in the investigation, and at whose plant the apparatus has been installed.

THE AUSTIN 20-H.P. MOTOR CAR AT OLYMPIA SHOW.

CONSTRUCTED BY THE AUSTIN MOTOR COMPANY, LIMITED, BIRMINGHAM.

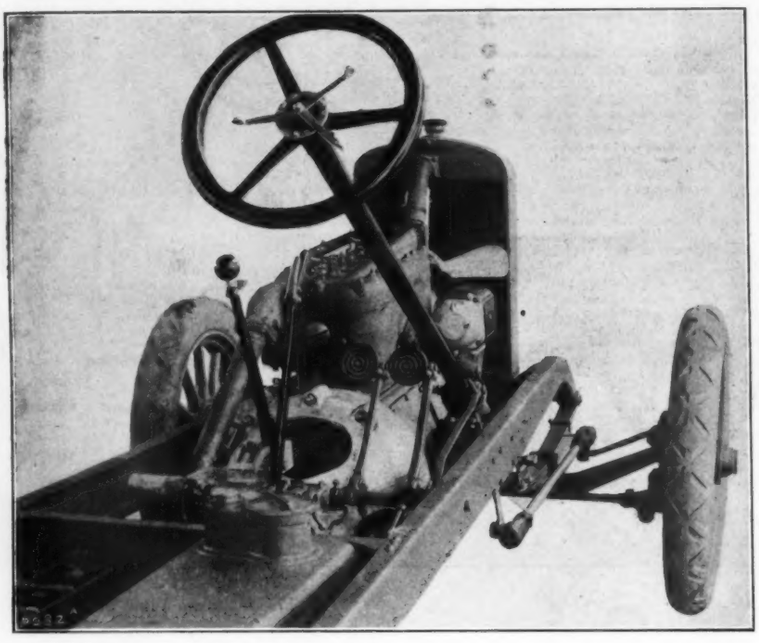


Fig. 1. Fore Part of Chassis showing Control Levers.

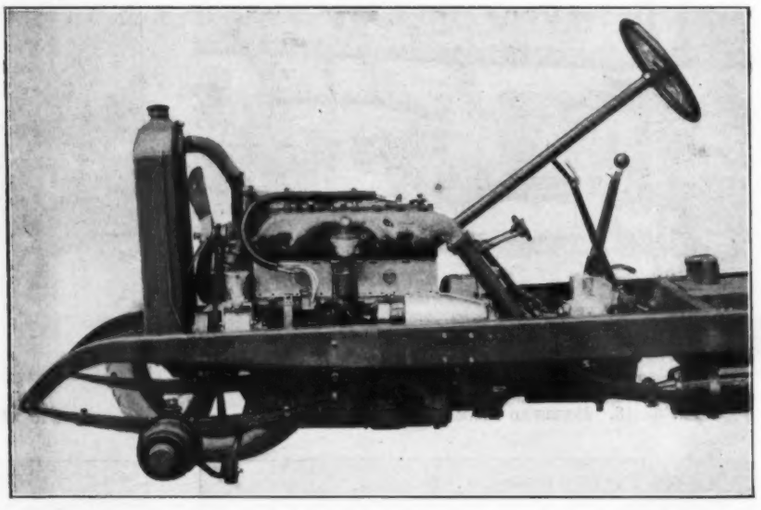


Fig. 2. Fore Part of Chassis: near Side

Flameless Gun Powders.—One of the problems which the Direction des Poudres set the French chemists in 1906 was to suppress the flame of gunpowders, notably the B.S.P. and B.G. 5, without impairing the ballistic power of the powder. The former object was soon attained with the aid of vaseline, Delpech reports in the *Comptes Rendus* of September 22, last, but it was only by a study of the firing trials that he became convinced that, when other materials were added to the powder, the powder charge had proportionately to be increased in order to secure the same ballistic effect as with the unmixed powder. The conclusion seems rather obvious that a powder containing a certain amount of a diluent non-explosive matter, could not be so powerful as the pure powder; and it is also a little surprising perhaps, that Delpech speaks of the materials as "antithermiques" and of "cold powders." He does not mention any temperature determinations, and one might imagine a suppression of the flame without a material lowering of the explosion temperature. The first materials tried was powdered charcoal; the effect was slight or nil. Then vaseline and other heavy petroleum greases were tried; these were successful, and it was found that about 3 per cent. of vaseline had to be used, and that in the 75 mm. guns, the charge of B.S.P. had to be increased by 4 per cent. to obtain the same ballistic effect. In the 105-mm. guns, and larger guns, the percentage of vaseline had to be raised to 6·5 and the powder charge to be increased by 6 per cent. or 8 per cent.; smaller vaseline percentages had in these cases hardly any effect. Naphthalene and mononitronaphthalene, used in percentages of 10 and 15, suppressed the flame, but gave red to dense black smoke. Trinitroxylene (xylite) answer is in the 75-mm. guns, not in the larger guns, but 25 per cent. of this material was required in any case. Cellulose, both from cotton and wood, extinguished the flame when present in smaller percentages (from 4 to 10), even in the 155-mm. guns; it proved difficult, however, to incorporate the filtered cellulose into the powder. Hydrocellulose, obtained as a fine powder, did not cause this trouble. But vaseline is on the whole considered the most suitable material for suppressing the flame, and it offers the further advantage that it stabilises the powder.

THE AUSTIN 20-H.P. MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY THE AUSTIN MOTOR COMPANY, LIMITED, BIRMINGHAM.

(*For Description, see opposite Page.*)

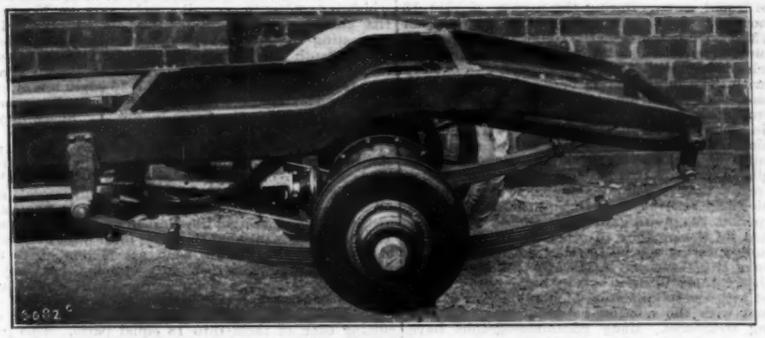


FIG. 3. VIEW OF REAR SPRINGING.

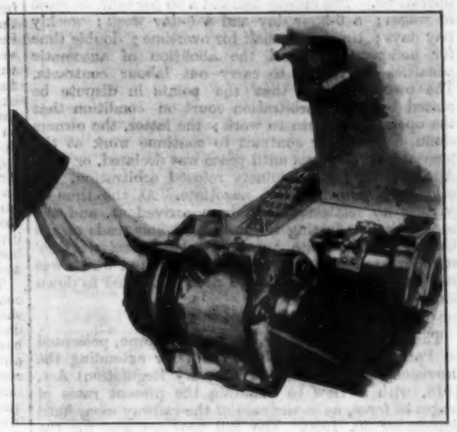


FIG. 4. VIEW SHOWING TIGHTENING OF PUMP AND MAGNETO CHAIN.

INDUSTRIAL NOTES.

IN our last issue we made reference to Lord Askwith's denunciation of the Labour Exchanges. The feeling in Leeds as to this institution is voiced in *The Yorkshire Post*, which says that in Leeds, especially in the engineering trade with its great number and variety of branches of work, the intervention of the Exchanges is found to serve no practical purpose. Sir John McLaren, president of the Leeds Chamber of Commerce, agrees that the present Employment Exchanges are entirely unnecessary, nor does he think that any such organisation can improve on pre-war methods. He adds that "the great majority of workers in the engineering trades do not change their places except at long intervals. We do not care to go to the Exchange, and take unknown men. We prefer, when setting men on to a job, to start old hands, or those who have worked for us before—men, whom we know, and who understand their work. The Labour Exchanges do not create employment; they can only make provision for change from one place to another; but that can be done very much more easily without their help. We got on all right without them before they came into existence. Regulation of employment was quite simple. We knew our men; and if we wanted to set on a few more, there was always some one in the works who knew of others, and the fact soon became known." Mr. F. J. Kitson stated that his views on Employment Exchanges coincided with those of Lord Askwith. Mr. J. E. Bedford, like Mr. Kitson, an ex-president of the Chamber of Commerce, confessed that although at first he was inclined to favour the idea of an Employment Exchange, he had, through experience, come to regard the system as unnecessary, and he was convinced that it was not a success. In his view, an intermediary of this kind was inadvisable. There was no better plan than that whereby a man in want of employment applied direct to the principal or manager of a firm. An official of the Leeds and District branch of the Amalgamated Society of Engineers, heartily welcomed Lord Askwith's strictures upon Labour Exchanges, whilst Mr. T. Heal, of the Carpenters' and Joiners' Society, said the members of his society were, to say the least, not very favourably disposed towards the Labour Exchanges.

Mr. J. W. Beynon, chairman of the South Wales Coalowners' Association, replied in Cardiff last Friday to speeches recently made by members of the Miners' Federation. (An abstract of Mr. Frank Hodges' speech is given in our last issue.) Mr. Beynon said that we had learnt to deplore the Government's cumbersome methods of doing business and their absolute disregard of the value of time. It would be difficult, he added, to convince a Government clerk that the adoption of departmental methods in the coal export trade would bring the collieries to a standstill in less than a week. Government control was a direct invitation to industrial suicide, for if coal were produced at a figure which prevented competition in the export trade, the purchasing power of this country would necessarily diminish and the cost of all foodstuffs and imports would increase to a marked degree. The economic language used by members of the Executive of the Miners' Federation would not be listened to in the markets of the world. We had to produce or we should perish industrially. It would be impossible, Mr. Beynon further stated, for a colliery agent or a colliery manager to carry out his arduous duties if interfered with by pit committees.

Mr. J. H. Thomas, M.P., addressed a meeting of railwaymen at Cambridge last Sunday, and, alluding to alleged back-door negotiations between the union and the Government, which he noticed were causing considerable alarm, said that the railwaymen had no objection to open negotiation. They had nothing to fear in that respect, but at the same time it would be wrong for him to lay himself open to the charge of having said something that would prejudice the negotiations. The discussions now being held were taking two forms. First, they were discussing standard conditions, just as if no strike had taken place. They were trying to establish what should be the standard conditions, no matter what the cost of living might be, and he hoped and believed there would be a satisfactory adjustment. Secondly, they were dealing with the old question of standardisation, and he hoped it would not be difficult to find a settlement satisfactory to all concerned. But he did not think this kind of negotiations was likely to establish industrial peace. They had boldly submitted to the Government's proposal—they might call it revolutionary if they liked—setting out that it was useless to ask the working classes to introduce a new spirit, unless it were frankly and fully recognised that they had to be partners in industry. They were saying to the railway companies, through the Government, that they insisted there should be some machinery in operation to permit the redress of the grievances of every grade, and to permit an equal number of the men's side and an equal number of the companies' side to thrash out these questions. "Over and above that," Mr. Thomas added, "we want to be really directors, and incidentally we are going to be railway directors. We believe that labour can contribute by its brains and experience to the solution of some of the employers' problems; the employer has difficulties which the workers ought to know. Neither side can know the other's difficulties unless they are in contact. It is on these lines, and in that direction, that we are at this moment discussing the position with His Majesty's Government."

The Scottish Railway Stockholders' Protection Association have sent a circular letter to members of Parliament, with reference to the negotiations between the Government and the railwaymen, expressing surprise that railway stockholders have in no way been consulted, and that no representation has been offered to them on the proposed joint management. Assuming that it is proposed by the Government that the suggested Railway Committee should include a representation of railway workers, the circular asks for the representation also of the stockholders. The object of the association is simply and solely to secure fair play for railway shareholders, who are viewing their future with considerable anxiety, owing to the uncertainty as to the Government's policy in regard to the permanent future of the railways. The circular points out also that the great majority of stockholders are small investors with a holding not exceeding 500*l.* nominal capital, and that while there are about 800,000 direct holders of British railway stocks, it is estimated that through trust, Friendly Societies, trade unions, and the like, the real beneficial owners of British railways number many millions.

The Institution of Municipal and County Engineers, 92, Victoria-street, London, S.W. 1, has addressed to county councils, metropolitan boroughs, boroughs, urban and rural districts, a leaflet in which it states that the position of young engineers whose training has been interrupted by military service has recently received the careful consideration of the council of that Institution. There is, it adds, a tendency at the present time to expect these young men to show a number of years of experience which it is impossible for them to do owing to the war; this results in deferring the attainment of any particular standard of salary to four or five years later than would have been the case had they not been serving their country, and thus imposes a permanent penalty on them for their patriotism. It should not be overlooked that although these men have missed some years of regular engineering training, yet, on the other hand, their characters and their power of managing men have been developed in a way which would have been impossible in civil life until many more years had elapsed; therefore, although their value, so far as technical training is concerned, may have been somewhat lessened by their military service, yet this is amply compensated for by their increased ability and experience in other directions.

The council of the Institution feels that these cases have only to be considered to receive the most sympathetic treatment, and the Institution asks the addressees to bring before their council any such cases under their authority, with a view to the removal of any disabilities such as those mentioned.

In the House of Commons last Monday, in reply to an inquiry by Major Birchall (Leeds, N.E., C.U.), the Minister of Labour, Sir R. Horne, stated that there were no statistics available to show the actual average earnings of piece and time workers in the ironmoulding trade in the period of four weeks preceding the strike. The minimum weekly time rates (inclusive of war wages) recognised in some of the principal industrial districts by the workers' organisations ranged from 67*s.* 6*d.* to 73*s.* 6*d.*, with a bonus of 12½ per cent. on earnings in addition. In some of the smaller centres the rates were rather lower. It was estimated, on the basis of such information as was available, that the total number of workpeople in the ironfounding, engineering and shipbuilding trades on strike or thrown out of work in consequence of the strike was approximately 100,000. In addition, a considerable number of workpeople were on short time. Sir E. Carson asked whether men who had been thrown out of work through no fault of their own were entitled to the out-of-work donation, when Sir R. Horne replied that the same rule applied as was applicable under the Unemployment Benefit Insurance Act. Men who belonged to the same establishment as those who were on strike did not receive the benefit, but those who belonged to establishments other than those to which the strikers belonged did receive the benefit. Sir R. Horne further stated that all matters of dispute went before the umpire for decision. The umpire had recently decided as a general principle that any department of an establishment which was thrown out of work by a strike could be regarded as a distinct establishment by itself, and

be treated as a separate department for the purpose of the unemployment donation. That was laid down as a general principle, but it rested with the umpire to decide each case according to its merits.

A coalminers' strike broke out throughout the United States last Saturday, involving over 400,000 operatives. The miners demand a 60 per cent. increase in wages; a 6-hour day and a 5-day week; weekly pay days; time and a half for overtime; double time for holiday work and the abolition of automatic penalties for failure to carry out labour contracts. The owners offered that the points in dispute be placed before an arbitration court on condition that the operatives return to work; the latter, the owners claim, were under contract to continue work at the present rate of wages until peace was declared, or until April 1, 1920. The miners refused arbitration, but said they were ready to negotiate. At the time of writing no settlement had been arrived at, and the coal strike is affecting seriously the whole trade of the United States, quite apart from the steel workers' strike we referred to on page 407 *ante* and which was still continuing when the coal miners decided to down tools.

The Minister of Labour, Sir Robert Horne, presented to Parliament last Monday a Bill for extending the provisions of the Wages (Temporary Regulation) Act, 1918, with a view to maintain the present rates of wages in force, as in the case of the railway men, until September 30, 1920. The Bill provides also for the establishment by Government of an Industrial Court to settle, with the consent of both parties, points in dispute similar in their nature and bearing to those the employers and the workpeople had hitherto been unable to settle. The Minister of Labour would also, under the Bill, appoint Courts of Inquiry into the causes of trade disputes, with a view to guiding public opinion into the circumstances leading up to such disputes. The provisions of the Bill have formed the subject of negotiations for several weeks past between the Government and representatives of trade unions. Conferences were held at the Ministry of Labour on October 31 and November 1, dealing with the provisions in question, and at the close of the latter conference, Mr. G. D. H. Cole, secretary of the trade unions' side of the Provisional Committee of the National Industrial Conference, said the situation was such that it had been decided to call a special conference of all the trades concerned, on Wednesday, the 5th inst.; he added that since the proposals affected the whole trade union movement, it had further been decided to invite the Parliamentary Committee of the Trade Unions' Congress to attend Wednesday's conference. At the latter a committee was formed to watch developments and to consider amendments to be moved when the Bill reaches the committee stage in Parliament.

Trieste Commercial Museum.—H.M. Consul-General at Trieste has received a request from the Trieste Commercial Museum to be supplied with books containing the addresses of the most important industrial and commercial firms of the United Kingdom and of the Colonies, as these are in great demand. The information should be sent direct addressed to His Majesty's Consul-General at Trieste and marked "Trieste Commercial Museum."

The Wireless Society of London.—This society held their first general meeting since the war at the Institution of Civil Engineers, on Tuesday, October 28. The meeting was attended by over 150 members and visitors. The president, Mr. A. A. Campbell Swinton, F.R.S., was in the chair and announced that owing to the resignation of Mr. R. H. Klein from the office of hon. secretary, which he had held since the foundation of the society, Mr. Leslie McMichael (30, West End-lane, West Hampstead, N.W. 6) had been asked, and had agreed, to take over the duties entailed. Mr. Klein had been elected an active vice-president. Admiral Sir Henry Jackson, G.C.B., F.R.S., one of the very earliest experimenters in wireless telegraphy had also been included, and was taking keen interest in the welfare of the society. Dr. F. C. Knight had been made a member of the committee. The meeting was invited to confirm these appointments, and by an amendment it was decided that the present officers and committee should remain during the year 1920, thus preventing the necessity of another election in January next. The president spoke of the loss sustained to the society by the death of Sir William Crookes, O.M., Mr. Russell Clark, O.B.E., Professor Silvanus Thomson, and Mr. Dudell; a number of other members had unfortunately lost their lives in the war. The matter of licences for wireless telegraphy was touched upon at some length, and it was pointed out that every effort had been and would be made, to influence the Post Office authorities to come to some decision, so that experimental work among amateurs might again be established. A letter was read from the Postmaster-General accepting the services of the Advisory Committee of the Wireless Society to assist in selecting suitable applicants for transmitting licences when these are permitted.

THE SOLIDIFICATION OF METALS FROM THE LIQUID STATE.*

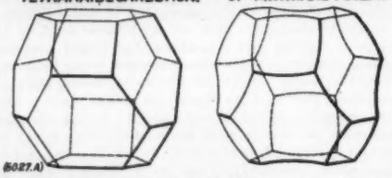
By Cecil H. Desch, D.Sc., Ph.D., Professor of Metallurgy in the Royal Technical College, Glasgow.

[The first report was presented to the Institute at the Spring Meeting of 1914,† and consisted of a review of the state of knowledge respecting the solidification of metals from the liquid state. During the session of 1914–15 the author had the valuable assistance of Mr. Solomon English, M.Sc., who came from the University of Sheffield as the holder of an 1851 Exhibition Research Scholarship, and much experimental work was carried out, mainly dealing with the solidification of beads of metal. These experiments were interrupted by the transfer of Mr. English to urgent war work, since when he has received an appointment in the Department of Glass Technology in the University of Sheffield. The author takes this opportunity of expressing his high appreciation of Mr. English's manipulative skill and scientific ability, and his regret that it was not possible to continue the work which had been begun. During the remainder of the war period, the investigation was almost completely interrupted by the pressure of other duties, but it has been resumed during the past winter session, with the assistance of Miss Catherine F. Davidson, B.Sc.

The observations hitherto made have been mostly concerned with the solidification of small masses or thin sheets, and with the relation between superficial and underlying structures. Many photomicrographs have been made, but it is considered desirable to postpone publication until a later report, as the phenomena are complex, and several difficulties demand further attention. The present interim report deals with two questions which offered themselves in the course of the investigations, namely, the form of crystal grains and their relation to foam structures, and the solidification of liquids exhibiting a cellular convection structure.]

The Form of Crystal Grains.—The investigation which forms the subject of these reports was undertaken at the instigation of Sir George Beilby to test the hypothesis of Quincke, according to which metals and other substances, immediately before solidification from the liquid state, separate into two immiscible liquids, one of which is formed in much smaller quantity than the other. These liquids have an interfacial surface tension, and a foam is formed, the liquid present in smaller proportion arranging itself in cell walls, and the second constituting the cell contents. Crystallisation then takes place within the foam cells, and the cell walls are represented in the solid mass by the boundaries of the crystal grains.

Fig. 1. Orthic Tetrakaidecahedron. *Fig. 2. Tetrakaidecahedron of Minimum Area.*



(5027.A)

If this were actually the case, the form of the crystal grains in a solid metal might be expected to approximate to that of the cells in a foam, such as is produced by blowing air through a soap solution, the shape of the cell walls in both cases being due to surface tension. The subsequent growth of the crystals forming the cell contents might distort the original cells, but could scarcely produce a complete change of type. It was therefore thought desirable to make an experimental comparison between the shape of metallic crystal grains and foam cells, and with this question the first section of the report deals.

The problem of the form of individual cells in a foam has received surprisingly little attention. The fundamental principles were established by Plateau in his classical investigations,‡ and may be stated as follows:—

(*a*) Only three films can meet in an edge, and they must make equal angles of 120 deg. with each other;

(*b*) Only six films can meet at a point, and adjacent edges must make equal angles of 109° 28′, with one another.

The foam being the result of surface tension, the area of each cell is necessarily a minimum for the given conditions.

The beautiful experiments of Plateau did not include the examination of a mass of foam. The arrangement of the dividing walls in a single layer of bubbles on the plane surface of a liquid may be considered to have been determined by him, and is easily shown to be a regular hexagonal pattern, but Plateau's remarks concerning a foam extending in three dimensions are confined to a statement that the above conditions of the meeting of films and of their edges must be satisfied.

A solution of the problem was obtained by Lord Kelvin.§ The most general solution for the homogeneous division of space was shown by him§ to be a tetrakaidecahedral cell, consisting of 14 walls, which may be plane or not plane. Eight of these are hexagonal and four quadrilateral, so that there are 36 edges and 24 corners. Each face is common to two neighbouring cells; each edge is common to three cells, and each corner is common to four cells. Any homogeneous assemblage of similarly-shaped and similarly-oriented objects, however irregularly shaped, may be divided from one another by similar cells of the above type, in such a way that every single object is completely enclosed in one cell. The simplest example of such a cell is one which is familiar in crystallography as a combination of the cube and octahedron. It may be obtained by truncating the six corners of a regular octahedron to such a depth that the eight original triangular faces are reduced to equilateral equi-angular hexagons. The six new faces are squares, and all the 36 edges are of equal length. This figure, which Lord Kelvin calls an orthic tetrakaidecahedron, is shown in Fig. 1. Space may be filled with cells of this kind.

Foam cells are subject to the further condition that the partitional area must be a minimum. The tetrakaidecahedron of minimum area has been shown* to have also eight hexagonal and six quadrilateral faces, all the edges being equal in length; but the latter, instead of being straight lines, are now similar plane arcs. The condition being that the edges must meet at an angle of 109 deg. 28 minutes, each arc is one of 19 deg. 28 minutes. It is not actually circular, but may be considered as such without serious error. The figure may be constructed very simply by bending two stiff brass wires into circles of about 15 cm. diameter, and cutting each of them into 18 equal parts. This gives 36 arcs of 20 deg. each, the difference between this value and 19 deg. 28 minutes being scarcely perceptible. These arcs may then be soldered together to form the required figure, a drawing of which is shown in Fig. 2. Such a wire model, immersed in soap solution, gives a giant foam cell, the faces of which have the required form. The hexagonal films are doubly curved, in such a way that the three diagonals are straight lines lying in one plane, and the sum of the curvatures in mutually perpendicular normal sections at any point is constant. A mass of foam built up of similar cells of the above shape would be stable.

The rhombic dodecahedron is a plane-sided polyhedron, of which each pair of sides meets at an angle of 120 deg., and space may be filled with equal and similar rhombic dodecahedra. Moreover, it is the only plane-sided polyhedron which fulfils these conditions, but foam cells of this form are unstable, since it involves the meeting of 12 plane films at a point, as the planes from the 12 edges of a cube meet at the centre of the cube. That such an arrangement cannot maintain itself is known from one of the most familiar of Plateau's experiments, in which a cubical wire skeleton frame is immersed in soap solution. The 12 films so produced, instead of meeting at a point, meet a small quadrilateral film near the centre of the cube. This film is plane, and has curved edges, the four angles being 109 deg. 28 minutes instead of 90 deg. Lord Kelvin showed that by blowing gently into one of the funnel-shaped apertures of the figure the small quadrilateral may be made to contract to a point, when the 12 films which meet there immediately rearrange themselves, so that a new quadrilateral film is formed at right angles to the original one and to the direction of blowing. The arrangement of 12 films meeting in a point is therefore one of unstable equilibrium, which may be departed from in three different ways.

When an actual foam is examined, the cells are found to vary considerably in shape, even when of fairly uniform dimensions. In making measurements for the present paper, four different materials have been used, namely, soap solution (in the form of Plateau's solution, containing glycerol, when stability was required), a resin soap solution prepared by dissolving resin in alcohol, precipitating with water, and dissolving in sodium hydroxide solution, a solution of ammonium oleate, and a warm solution of gelatin in water, the last mentioned being used when a permanent foam was desired. Molten resin was tried, but with less success. The forms of the cells were found to be essentially the same in all cases.

In order to prepare a foam, some of the solution is poured into a glass trough with plane parallel sides, and air is blown through it by means of a narrow pipette until the trough is filled with foam. When a fairly stable condition has been reached, single cells are examined by placing the trough in front of a window, screening it with a sheet of black paper having a hole about 2 cm. in diameter, so that the attention is more easily concentrated on a single cell. An attempt is then made to count the cell walls, and to record the number of edges of each face. This is done for as many cells as possible. The direction of curvature of the walls may often be recognised by the arrangement of the bands of colour under illumination. A second method consists in making a foam from a warm solution of gelatin, of sufficient concentration to set on cooling. The foam cells are thus fixed, and may be examined at leisure, each cell being cut open and examined in turn by using fine-pointed dissecting scissors. Both methods have been employed in obtaining the results shown later. Cells in contact with the glass must, of course, be excluded from the count, but they have been examined separately, and some figures derived from them are included in a later section.

Even a casual examination of a mass of foam shows that the individual cells vary in form, but however irregular they may appear, it is easily seen that the faces and edges fulfil the conditions established by Plateau. Occasionally, when movements are in progress in the midst of the mass, four films may be seen to meet in one edge, but the position is unstable, and sliding immediately takes place until equilibrium is reached. The

* Second Report to the Beilby Prize Committee of the Institute of Metals, submitted at the meeting held on September 11, 1919.

† *Journal of the Institute of Metals*, No. 1, 1914, vol. xi, page 57.

‡ J. Plateau, *Statique experimentale et théorique des liquides*. 2 vols. Ghent, 1873.

§ *Proceedings of the Royal Society*, 1894, vol. lv, page 1; *Collected Papers*, vol. v, page 333.

* *Philosophical Magazine*, 1887, vol. xxiv, page 503; *Collected Papers*, v, page 297.

vertices of large cells are often truncated, and a small cell is then interposed between the larger neighbours. Such transitional cells are either hexahedra, elongated in one direction, and having the edges slightly curved so as to make angles of 109 deg. 28 minutes with one another instead of 90 deg., or tetrahedra, the edges of which must be strongly curved.

The results of observations of several masses of foam, prepared at different times and by different methods, are given in Table I. That the number of faces to a cell should vary considerably was to be anticipated, as the

TABLE I.—*Structure of Foams.*

Material.	Average Number of Faces to each Cell.	Number of Sides to a Face.					
		3.	4.	5.	6.	7.	8.
Plateau's solution ..	13	2	52	128	57	18	—
Ammonium oleate ..	13	1	54	130	64	10	—
Soap solution ..	—	3	23	39	18	—	—
Soap solution ..	—	4	36	87	53	12	2
Gelatin	10·5	—	18	30	6	3	—
Gelatin	10·0	1	10	26	13	1	2
Gelatin	9·0	2	18	20	6	1	—
Gelatin	11·0	8	41	46	35	6	—
Gelatin	—	—	16	40	17	—	—
Totals		21	268	552	269	51	4

(The first two preparations, in which the largest number of cells was counted, were the most regular in structure. Some cells proved to be complete pentagonal dodecahedra. The gelatin preparations, no doubt owing to viscosity, were the most variable.)

cells vary in size with the accidental conditions of their formation by blowing, and therefore pack irregularly, but it is at first sight surprising that an approximation to Lord Kelvin's tetrakaidecahedron should be so rare. If this were the usual type of cell, four and six-sided cell walls would occur with frequencies in the ratio of 6 to 8, but the observations show that five-sided faces are much more common than either, and that hexagonal faces are comparatively infrequent. The cells often approach very closely to the form of a regular pentagonal dodecahedron (Fig. 3). This figure has faces with five equal angles of 108 deg., thus coming very near to the required angle of 109 deg. 28 minutes, and adjacent faces meet at an angle not far from the equilibrium value of 120 deg. A slight curvature of the edges therefore converts the pentagonal dodecahedron into a possible figure of equilibrium for a foam cell. It is notpossible to fill space continuously with such regular dodecahedra, but where polyhedra of varying shape are packed together as in a foam, subject only to the conditions expressed by Plateau's rules, it is easily seen that such a figure may occur very frequently.

The next step is to examine the forms of crystal grains in cast metals, and to determine how far they correspond with those of foam cells. For reasons discussed later, it is by no means easy to infer the shape of the grains from that of their sections as seen in the ordinary microsections, and it is therefore desirable to isolate single grains for examination. For this purpose advantage was taken of a fact mentioned by Professor Huntington in the discussion on the previous report,* that β-brasses containing aluminium, when immersed in mercury, separate into distinct grains, the mercury penetrating between the grain boundaries. A suitable mass of metal was available, in the form of a portion of a marine propeller which had broken in use, exhibiting a very coarse fracture. The structure was homogeneous, only the β-constituent being visible. On immersion in mercury, the metal disintegrated in the course of a minute or two, the grains separating cleanly from one another, and the whole mass crumbling like sand. The grains thus isolated had a brilliant, silvery surface, owing to amalgamation. They could be examined under a hand lens, each face being marked with a dot of ink after noting the number of its sides and the direction of its curvature. The results of the examination of 30 of these grains are shown in Table II. The number of faces is usually large, varying from 11 to 20, with an

* *Journal of the Institute of Metals*, No. 1, 1914, vol. xi, page 108.

TABLE II.—*Grains in Propeller Brass in β-Condition.*

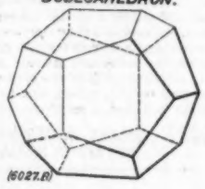
Material.	Average Number of Faces to each Grain.	Number of Sides to a Face.					
		3.	4.	5.	6.	7.	8.
—	14·5	11	88	190	123	20	3

average of 14·5. Generally speaking, the larger grains are the more complex. The faces are mostly curved, and double curvature, recalling that of foam cell walls, is frequent. It will be seen that there is a great preponderance of pentagonal faces. The figures are plotted in Fig. 4 for comparison with those given by the counting of cells in soap and gelatin foams, and the general resemblance of the two curves will be noticed.

Attempts have also been made to separate other metals in the same way. A small specimen of brass of the following composition :—

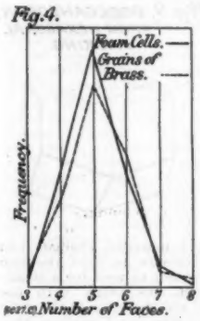
Copper	60·0
Zinc	37·75
Aluminium	2·0
Manganese	0·25

Fig.3. PENTAGONAL DODECAHEDRON.



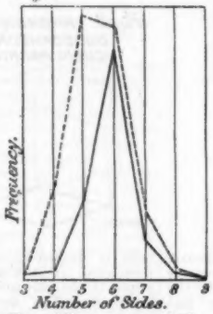
(6027.B)

Fig.4.



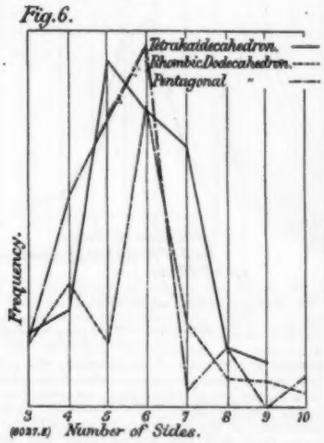
(6027.C)

Fig.5.



(6027.D)

Fig.6.



(6027.E)

was brought into the β-condition by quenching. On immersion in mercury it disintegrated in the same way as the former specimen, but much more slowly. The grains were quite similar in form to those given in the table, but the number available was small, and it was not thought worth while to present the figures separately.

A piece of α-brass, which had been cracked by hot forging, and had the appearance of a mass of loosely-united fibres, was tested in the same way, and although the structure was already so loose that the fibrous crystal grains could almost be torn apart, mercury had no effect in bringing about further separation. Cast zinc, tin and lead were gradually corroded by prolonged immersion in mercury, without any separation into grains.

A mass of iron which had cooled inside a slag ball was also examined. The grains exposed on a fractured surface were unusually coarse, some of the facets being as much as 1 cm. across. A light blow easily detached some grains, but they were not sufficiently perfect for measurement, as the fracture did not invariably follow the grain boundaries, so that original boundaries and cleavages were confused. The facets on the fracture seen in the photograph were often irregular, with complex curvature. Confining attention only to those which were fully exposed and well defined, 3 facets were seen having 3 sides, 13 with 4, 8 with 5, 6 with 6, and 4 with 7 sides. Microscopical examination of a section showed it to be pure ferrite, free from inclusions other than slag, and traversed in places by numerous Neumann lines. Boiling a slice cut from the specimen in strong sodium hydroxide solution was without effect on the separation of the grains.

The preceding remarks concerning the forms of foam cells and crystal grains are only applicable to cells which occur in the midst of a large mass, and are therefore independent of boundary condition. Where the wall of a foam cell meets a solid surface, such as the glass of the containing vessel, it does so at an angle of 90 deg. The partitioning of neighbouring cells is still subject to the condition that only three walls can meet at an edge, and that the angle between them must be 120 deg. The most natural arrangement then becomes a regular hexagonal pattern. Actually, as the cells vary in size, polygons having a variable number of sides are observed, but the hexagonal form predominates. Figures for soap and gelatin films are given in Table III, and are represented graphically in Fig. 5.

TABLE III.—*Cells in Contact with Glass.*

Material.	Number of Sides to a Cell.						
	3.	4.	5.	6.	7.	8.	9.
Soap solution ..	1	8	12	55	15	3	—
Soap solution ..	8	10	55	100	28	7	—
Gelatin	—	1	17	22	2	3	1
Totals	9	19	84	177	45	13	1

A convenient metallic object for comparison was a small ingot of crucible steel, the fracture of which showed dendritic crystals extending from the four surfaces to the centre of the ingot. One of the outer faces was polished and etched, so giving a transverse section of the dendritic crystals close to their origin. The polygonal outlines thus exposed were examined as above and the results are shown in Table IV and Fig. 5. Some of the grains were very complex, and it is probable that a certain amount of coalescence takes place between neighbouring dendrites, giving rise to compound grains, the outlines of which are more or less irregular.

TABLE IV.—*Grain Boundaries at Cooling Surfaces of Ingot.*

Material.	Number of Sides to a Cell.						
	3.	4.	5.	6.	7.	8.	9.
Crucible steel ..	5	44	93	93	27	6	1
Crucible steel ..	3	44	135	126	32	2	—
Totals	8	88	228	219	59	8	1

Whilst it has only been found practicable to examine isolated crystal grains in exceptional cases, it is always possible to make plane sections through the metal, and to examine the shape of the grain boundaries exposed in that section by etching. Such boundaries often have a simple polygonal form, and it would appear at first sight that it should be possible, by counting the sides of a sufficiently large number of polygons, to infer from the result the probable form of the polyhedra of which they are the sections, provided that those polyhedra are either similar or vary closely about a mean type. Unfortunately, the problem of establishing a relation between the form of a polyhedron and that of its plane sections proves to be peculiarly difficult. The mathematical problem on which the solution depends may be stated simply. It is : Given the form of a polyhedron, what is the probability that a plane section, drawn through it at random, will have 3, 4, 5, . . . n sides ? A general solution, even for a simple case, such as a cube, does not appear to be possible. One is therefore reduced to some geometrical expedient, such as selecting a sufficient number of straight lines passing through the centre of the solid, and taking plane sections perpendicular to such lines, and at regular intervals along them. In order to arrive at the probability, it is evident that an infinite number of lines would have to be taken, and when only a finite number is employed, there is no guarantee that the distribution so arrived at is a representative one.

A few calculations have been made in this way for the case of the cube, but the process is very laborious, and would be out of the question for the more complicated solids. A rough experimental method has therefore been adopted, models of the polyhedra being made in cardboard, and rendered waterproof by paraffin wax. By immersing these in water, plane sections are realised by the intersections of the model, placed in various positions, with the surface of the water. Placing the model with a selected line vertical, it is immersed by successive equal steps, such as 1 cm., and the form of the intersection is noted at each step. The solid having certain conditions of symmetry, each vertical line thus employed corresponds with a definite number of similar lines, and the numbers obtained in one set of measurements may be multiplied by a factor. Experiments of this kind have been made with models of the rhombic dodecahedron, pentagonal dodecahedron and orthic tetrakaidecahedron. As an illustration of the method adopted, the first of these solids may be taken. The model may be immersed with one face horizontal. The height of the model employed being 13 cm., 14 sections at distances of 1 cm. are obtained, of which 8 are four-sided and 6 are six-sided. As there are 12 rhombic faces, to any one of which the section might be parallel, these numbers must be multiplied by 12. Similarly, any one of the 24 edges might be placed horizontally, like the ridge of a roof, or a vertex might be placed uppermost, there being 8 trihedral and 6 tetrahedral vertices. A vertex being tilted to one side, a fresh set of observations is made, and so on. The curve drawn in Fig. 6 represents the relative frequency with which each section occurs, a total of 1,732 sections having been used for its construction. The curves for the other polyhedra have been constructed in the same way.

As above remarked, there is no certainty that sections thus arbitrarily chosen will be distributed in the same way as those found at random, but the number taken is large, and it seems worth while to test it for the purpose of the present paper. Small errors may also be introduced by accidental irregularities in the models, as when, for instance, two vertices, which should be at the same level, are not exactly so, the effect is to produce some sections with a larger number of sides than corresponds

with the exact geometrical figure. This source of error is probably not very serious.

The metal specimens used for comparison with the above figures included the same brasses which had furnished the isolated grains, two pieces of very mild steel, having polygonal grains with remarkably straight boundaries, and several miscellaneous specimens which were used for purposes of comparison. The results are shown in Table V, and are represented graphically in Fig. 7.

TABLE V.—*Crystal Grains seen in Plane Sections.*

Material.	Number of Sides to a Grain.						
	3.	4.	5.	6.	7.	8.	Over 8.
Mild steel rod ..	5	61	299	245	93	16	7
Mild steel casting ..	4	17	67	64	7	—	—
Propeller brass ..	9	24	57	70	36	18	6
β-brass ingot ..	9	50	137	102	43	6	—

An examination of the tables and curves makes it evident that little information is to be gained from a study of the cross-sections of crystal grains, at least until greater certainty can be reached as to the relation between the form of a polyhedron and the probability that a section cut through it at random will have a given number of sides. If the curves shown in Fig. 6 represent anything like the proper distribution, it would be difficult, if not impossible, to infer which was the true form of the polyhedron approaching most nearly to the average crystal grain, as the distribution of 3, 4, 5, &c., sided sections is not sufficiently characteristic.

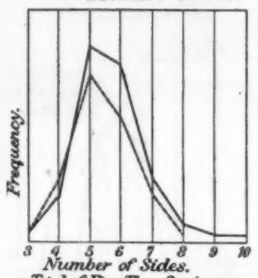
On the other hand, the examination of isolated grains and a comparison of them with foam cells leads to more definite conclusions. If we suppose that surface tension has nothing to do with the form of the crystal grains, but that these are determined solely by growth from centres, a conclusion may be reached as to the form to which such grains should approximate. If the distribution of the nuclei from which crystal growth proceeds be independent of boundary conditions, and governed only by the laws of probability, it seems likely that in a sufficiently large mass the nuclei should be approximately equidistant. This would be equivalent to the close packing of a large number of spheres. It is known that such close packing may take place in one of two ways, known respectively as the cubic and the hexagonal. If we imagine closely packed spheres to be made of some deformable substance, such as plasticin, and pressure to be then applied so as to close up the interstices, a mass of polyhedra will result. Cubic packing leads to the formation of regular rhombic dodecahedra, and hexagonal packing to that of dodecahedra which have certain of their faces no longer rhombs, although still quadrangular. (See Figs. 8 and 9.*) Whichever were formed, the grains would have quadrangular faces, and in a mass of metal solidifying under such conditions the grains might be expected to show a preponderance of four-sided faces. This is not confirmed by the observation of grains isolated by the mercury method. If, however, the form of the grains were determined by surface tension, they might be expected to approach more closely to the pentagonal dodecahedron, or to the tetrakaidecahedron, or to some compromise between the two. This is confirmed by the results shown in Fig. 4, there being a marked preponderance of faces with five edges, followed by six and four.

There is thus evidence that the forms of the crystal grains in at least some metals are such as might be expected if surface tension were concerned in their determination. On the other hand, it is well known that many crystal grains are less simple, and exhibit complex interlocking. There is a striking difference between α- and β-brasses in this respect. α-Brasses usually have interlocking boundaries, and rarely approach simple polyhedral forms. Iron and steel may form either polyhedra or interlocking grains, according to circumstances. One is forced to the conclusion, previously expressed by the writer,† that two forces are competing in the formation of crystals. One is the directive force of cohesion, sometimes called the crystallising force, and the other is surface tension. The ratio which the one bears to the other varies with the nature of the crystalline substance, the temperature of crystallisation, the composition of the mother liquor, and the absolute dimensions of the mass of the solid. When the mass is very small, so that the surface is large relatively to the volume, the surface forces may be so great as to mask the crystallising tendencies completely. This aspect of the subject has been specially studied by Sir George Beilby.‡ With large masses the other factors become more important, and the specific differences between different metals become particularly noticeable. This feature will form the subject of a later report. It will be seen, however, that a metal which has a great power of orientation will be likely to form interlocking grains, as the boundaries will be chiefly determined by the growth of the crystallites, whilst a second metal, in which the orienting forces are weaker relatively to the surface forces, will tend to form grains of a simpler character, surface tension intervening to check the growth. The factors which govern the relation between the two forces are, of course, still very obscure.

Reference may here be made to one case in which an isolation of crystal grains has been effected, but in which only complex forms have been observed. This is the case of glacier ice, the crystals of which have not been formed directly from the liquid state, but reformed from the original minute snow crystals by successive partial fusion and relegation under the influence of non-uniform pressure. The action of sunlight sometimes causes a mass of glacier ice to disintegrate into grains, which are readily separated from one another. These grains do not appear to be of simple form, but interlock in a complex fashion. "The shape of the grains is irregular, and no two of them are alike, but they fit into each other like a puzzle. They resemble a collection of vertebræ more than anything else."* It is not proved that such disarticulated masses, which vary in size in a single mass of glacier ice from 1·5 grammes to 700 grammes, are actually single crystal grains, and it may well be that they are aggregates of smaller units, but they are differentiated from the general mass by the ready fusion of the thin sheath of eutectic surrounding them, so that sunlight etches the outline of the grains on the inner surface of a grotto, revealing interlocking boundaries curiously resembling the sutures of the cranial bones.† It is quite possible that two orders of cellular structure are here present, this being a feature common to many solidified masses, both metallic and non-metallic.

Cellular Convection and Crystal Grains.—The phenomena of cellular convection in a layer of liquid having its upper and lower surfaces at different temperatures were described in Section 4 of the former report.‡ The conclusion was there reached that the formation of cells in this manner could not account for the ordinary types of cellular structure in solidified metals as distinguished from a basaltic structure, since the formation could only occur in horizontal layers, giving rise to vertical prisms of approximately hexagonal section. Dauzère observed

Fig. 7. PLANE SECTIONS OF METALLIC GRAINS.



that certain waxes, when allowed to cool in horizontal layers, so that convection cells were formed, retained the pattern on solidification. This may be explained by the difference of temperature between the centre and periphery of a cell. The structure of a convection cell necessitates that the central ascending column should be at a higher temperature than the peripheral descending layer. As the mass cools, therefore, undercooling will occur first at the boundary of the cell, and crystals will make their first appearance there, and gradually grow inwards towards the centre of each cell.

It seemed worth while to make a few experiments to determine whether a measurable difference of temperature, sufficient to bring about such a preferential solidification, could actually be found. For this purpose, mixtures of beeswax and paraffin wax were used, as in the experiments of Bénard and Dauzère, the cells being rendered visible by the addition of fine particles of flaky graphite or aluminium powder. The vessel was of copper, being a thick copper plate, provided with levelling screws, and a flanged ring attached to it by bolts. This was wrapped round with layers of felt, and heated on a steam bath provided with baffle plates, or subsequently on an electric plate heater, contact being made by sheets of lead foil.

Differences of temperature were determined by means of a double thermo-junction. Two long, thin copper wires are joined by about 20 cm. of Eureka wire of the same thickness, the two junctions being made by welding in the blowpipe flame with the aid of a particle of borax. It is necessary to avoid fusing to a globule, in order to make the thermal capacity of the junction as small as possible, and care must be taken to make the two welds exactly similar. The wires are then bent so that the two junctions are near together, and the wires are vertical and parallel. The last 10 cm. of each copper wire is then enclosed in a capillary glass tube for insulation, and each couple is enclosed in a thin outer tube of glass or silica, leaving 5 mm. or 6 mm. projecting at the lower end, the actual weld being the lowest point. These two tubes are mounted in such a way that they may be moved closer together or farther apart, while remaining parallel, whilst the combination of the two may be raised or lowered by rack and pinion, and also moved freely in a horizontal plane. The remote ends of the copper wires are connected to the galvanometer wires through a cold junction of the usual form. The galvanometer is of the suspended coil type, and is read by means of a mirror and scale.

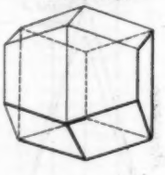
In making an experiment, the two junctions are brought to the same level by racking the combination down until the ends are in contact with a levelled glass plate. It is advisable to fix each wire in position by a drop of sealing wax to prevent accidental shifting. Two vessels containing water are then brought up under the junctions, and the latter are immersed to a depth of 1 mm. or so. The temperature of the water is determined by two mercury thermometers reading to 0·01 deg. C., previously compared. When the contents of the two vessels are at the same temperature, the thermo-E.M.Fs. of the two junctions exactly balance one another, and the galvanometer shows no deflection. The instrument is calibrated by raising the temperature of the water in one of the vessels, most conveniently by immersing an electric glow lamp in it for a few seconds and stirring well. The deflection of the galvanometer for a number of differences of temperature is thus determined, and controlled by reversing the water vessels. In the best series of measurements the deflection amounted to 8·5 mm. of the scale for each degree C. of difference of temperature between the two junctions, and this deflection was practically the same whether the actual temperature of the water were 17 deg. or 60 deg.

For measurements with wax, the measuring apparatus is brought over the trough containing the wax. It was found difficult to obtain a steady zero, owing to the effect of currents of steam or hot air from the bath playing unequally on the two junctions. It was for this reason that an electric plate heater was substituted for the steam bath. The wax having reached a fairly steady state, a cell is selected, the double couple is then brought over it in the appropriate position and lowered until the tips are just immersed in the liquid and no more. It is necessary that they should be exactly on a level, otherwise one will enter the liquid before the other, and a swing of the galvanometer will result.

Owing to the fact that the wires of the thermocouples conduct heat away from the wax, they must not be immersed for long, or the arrangement of the convection

Fig. 8. RHOMBIC DODECAHEDRON. (CUBIC PACKING.)

Fig. 9. DODECAHEDRON FROM HEXAGONAL PACKING.



(80276)

cells is disturbed, and the boundaries change their positions. It is therefore necessary to read the first swing of the galvanometer and not to wait for a steady deflection. The first readings are taken with one junction in the centre of a cell and the other at the outer boundary of the same cell. The junctions are then interchanged, so that the difference of temperature is in the opposite sense, and the deflection should of course be equal to the first, but in the opposite direction. There is some difficulty in obtaining exactly equal deflections, largely owing to the indefiniteness of the external boundary of a cell, there being frequently an area of "dead water" which does not appear to participate in the movement. For the purposes of control, other measurements are made with both junctions in central columns, or with both in boundaries. There should in either case be no deflection. It was found in practice that from centre to centre the deflection was either zero or at most two or three divisions of the scale, but readings from boundary to boundary, for the reason just stated, were apt to vary irregularly. When care was taken to select exactly corresponding positions, however, and as little disturbance as possible was produced, the deflections became very small as compared with those obtained when one junction was at a centre and the other at a boundary.

The figures obtained are too irregular to justify reproduction in a table, but the results of several series of measurements may be summarised as follows. With the double junction mentioned above, giving a deflection of 8·5 mm. for a difference of temperature of 1 deg. C., and a layer of liquid wax 5 mm. deep, the convection cells tested having an average diameter of 18 mm., the observed deflections were :—

	Mm.
Between two centres	0
Between opposite boundaries	12 (frequently 0)
Between centre and periphery of the same cell	54

The latter value corresponds with a difference of temperature of 6·3 deg. C. Although no importance can be attached to the actual figure, it is believed that it is of the correct order, and that there exists a difference of several degrees between the temperatures of the summit of the ascending column and of the peripheral descending layer in a convection cell of the dimensions named. It must, of course, be remembered that the wax used is of low thermal conductivity and has an appreciable viscosity. It is probable that the differences of temperature in a mobile fluid of high conductivity, such as a molten metal, would be considerably less. The results obtained, however, suffice to explain why crystallisation begins at the periphery of the cells, provided that the

* W. Barlow and W. J. Pope, *Transactions of the Chemical Society*, 1907, vol. xci, page 1158.

† *Proceedings of the Royal Philosophical Society of Glasgow*, 1912, vol. xliii, page 114.

‡ Proceedings of the Royal Society, 1903, vol. lxxii, page 226.

* J. Y. Buchanan, *Antarctic Manual*, 1901; *Comptes Rendus of Observation and Reasoning*, page 48. Cambridge, 1917.

† Good photographs are given by J. Y. Buchanan; *Proceedings of the Royal Institution*, 1909, vol. xix, page 243, *op. cit.*, page 233.

‡ *Loc. cit.*, pages 75 to 81.

latter retain their existence until the temperature has fallen to that of solidification. In many cases the convection becomes sluggish, and may even cease, before the liquid has cooled sufficiently for crystallisation to begin.

A few measurements were also made with a strong solution of soap, as used by Professor James Thomson in his original experiment. The solution was poured into a vessel while hot, forming a layer 3 cm. deep, and the whole was allowed to cool until the convection cells became comparatively steady. It was not found possible to obtain such steady conditions as with the much shallower and less mobile layer of wax, but the boundaries were easily visible, the silky soap particles defining the motion very clearly. The difference of temperature at the surface between the centre and the periphery of an average cell, 3 cm. in diameter, was from 1 deg. to 1·5 deg. C.

It may be mentioned that the formation of cells in liquids and suspensions, either through differences of temperature or through evaporation from the surface, formed the subject of a correspondence in *Nature* in 1914,* which showed that many persons had observed the phenomenon, without being aware of the researches of Bénard, or of the earlier work of James Thomson. A mathematical study of the conditions in Bénard's experiments was undertaken by Lord Rayleigh, to whom we owe one paper on the subject,† in which, by making certain simplifying assumptions, the conditions under which instability in a mass of liquid heated from below will occur are determined mathematically. This paper marks a great advance in the knowledge of the phenomenon, and but for the lamented death of Lord Rayleigh it is likely that the solution would have been carried to a further stage.

Summary.—To sum up the present report, it is believed that evidence has been obtained that surface tension has an important share in determining the form of the crystal grains in a solidifying metal, and that such grains have a tendency to assume the shape of foam cells. This conclusion, whilst consistent with the hypothesis that foam cells are actually formed, is not in any way to be regarded as establishing that hypothesis, since it is equally in accordance with the solidification of the metal from nuclei, surface tension competing with the directive force of crystalline cohesion in determining the grain boundaries. The point at issue must be examined by other methods.

The experiments on convection cells have shown that the local differences of temperature required by the theory actually exist, but it is evident, in contradiction of statements made by several authors, that this phenomenon is without importance in the solidification of ordinary masses of metal. Its bearing on the solidification of thin sheets will be considered in a later report.

The programme of experimental work includes the completion of certain investigations which have already made considerable progress, into the relation between superficial and deep-seated structures in thin masses, and into the variation of surface tension in solid metals with temperature. It is also proposed to examine in detail the relation between the surface tension of metals and their absolute dimensions, and to make a study of the thermal changes immediately preceding as well as accompanying solidification. Work on these lines is in hand. Further experiments on the isolation of crystal grains will also be made.

Merchandise Marks Committee.—The President of the Board of Trade has appointed a committee to consider: (1) Whether any extension or amendment of the Merchandise Marks Act is required in respect of the provisions relating to indications of origin; (2) the utility and effect of national trade marks or other similar (collective) marks, and how far they should be authorised or encouraged in this country; (3) how far further international action may be necessary for the purpose of preventing the false marking of goods. The chairman of the committee is Mr. Harry Green, M.P., and the members comprise representatives of the Association of Chambers of Commerce, representatives of the Federation of British Industries, and a representative of the Irish Industrial Development Association. The secretary is Mr. M. F. Levye, of the Industrial Property Department of the Board of Trade, and all communications on the subject of the committee should be addressed to him at the Patent Office, 25, Southampton Buildings, W.C. 2.

Institution of Municipal and County Engineers.—It has been decided to take advantage of the large assembly of representatives of local authorities and their engineers and surveyors at the Roads Congress and Exhibition in November, to hold a Housing Conference on November 27, at the Royal Agricultural Hall, Islington, with the object of solving difficulties which may have arisen in dealing with the housing problem, and removing misapprehensions. The programme includes a short address by the Minister of Health (the Right Hon. C. Addison, M.D., M.P.) and the reading of papers on "Army Huts as Dwellings," by Mr. E. Y. Harrison, A.M.Inst.C.E. (Ipswich); "Munition Huts and Homes—Temporary Housing Scheme," by Mr. R. Hampton Clucas (Hammersmith); "Some Knotty Points in the Housing Problem," by Mr. A. H. Campbell, M.Inst.C.E. (Edinburgh); "The Six-Roomed House: Factors Governing its Design," by Mr. P. T. Harrison, A.M.Inst.C.E. (Chelmsford); "Notes on the Preparation of Housing Schemes," by Mr. L. Leeper, B.E., A.M.Inst.C.E. (Blyth).

---

* Letters by Professor Kerr Grant, Sir J. Larmor, H. Wager and others.

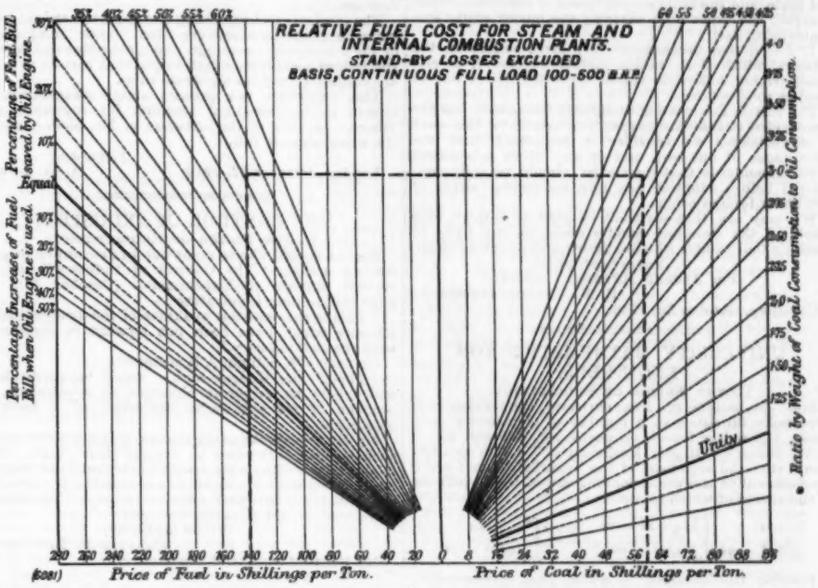
† *Philosophical Magazine*, 1916 [vi], vol. xxxii, p. 529.

SAVING IN FUEL BILL ON OIL-ENGINED VESSELS.

To the Editor of Engineering.

Sir,—Time was when marine engineers looked askance at marine oil engines, and the more the oil engine economy was demonstrated the more they clung to the well-tried steam machinery. But in spite of the quite understandable prejudice which enlarged every small difficulty met with by motor vessels into damning evidence of their false economy, it is being slowly but surely realised that motor vessels operated with foresight and understanding must and do give bigger profits on the yearly running than steamers. The existing coal situation brings the question into unusual prominence.

The question of the relative fuel costs has been gone into in print times without number, but always the fixing of market prices of coal and oil fuel has given room for inaccuracy and doubt as to the fair comparison. The accompanying diagram is of interest and utility in obtaining a quick comparison of fuel costs, given the relative costs of coal and oil and the relative consumptions by weight.


RELATIVE FUEL COST FOR STEAM AND INTERNAL COMBUSTION PLANTS.
STAND-BY LOSSES EXCLUDED
BASIS, CONTINUOUS FULL LOAD 100-500 B.H.P.
Percentage of Fuel Bill saved by Oil Engine.
Percentage increase of Fuel Bill where Oil Engine is used.
Equal
Ratio by Weight of Coal Consumption to Oil Consumption.
Unity
Price of Fuel in Shillings per Ton.
Price of Coal in Shillings per Ton.

The following is an example, and the prices are those now obtaining on the Thames:—

Comparison of 300 *Brake Horse-Power Bolinder Hot Bulb Oil Engine and* 300 *Compound Condensing Steam Set.*

Consumption of fuel oil per Brake horse-power for the oil engine ...	= lb./B.H.P. hour 0·57
Coal per shaft horse-power for steam set	= lb./S.H.P. hour 2·75
Ratio of fuel used by weight	= 4·80
Cost of fuel oil per ton	140*s.*
Cost of steam coal per ton	60*s.*

Turning to the diagram, take vertical line through coal cost of 60*s.* per ton, and where it meets line corresponding to weight ratio of 4·80, take a horizontal across to left hand of diagram. This strikes the 140*s.* vertical line at a point corresponding to the 51½ per cent. oil economy line, so that the oil engine saves over half the fuel bill of the steamer, without considering the stand-by losses.

Stand-by Losses.—With the average small craft, such as coasters, lighters and, more particularly, tugs, tenders pilot boats, &c., the stand-by losses of the steam machinery are very appreciable indeed. For a coaster doing 48-hour trips the stand-by losses would be something like 7 per cent. of the running fuel consumption. All modern hot bulb oil engines are so arranged that with the exception of having paraffin lamps alight to heat the bulbs on hot-bulb engines for starting purposes only, no fuel is consumed unless the engine is running.

Crews' Hours.—It is of no small advantage that the simple hot-bulb engine can be got under way with full load, 15 minutes after the driver enters the engine-room for the day's work.

Now, if the oil engine is going to effect such a great saving in fuel, save the driver's time by only requiring 15 minutes to get under way, and take up less space and weight of the vessel for the same power, why is the oil engine not more widely adopted? What is standing in the way of its rightful development in shipping? Despite many successes and highly profitable results the oil engine is not used nearly so widely as is warranted by results in efficient and competitive cargo carrying.

The distrust of any new development which is inherent in a conservative people has much to do with the problem, and it is well to realise that this conservative attitude is in a great degree a virtue. But it amounts to short-sightedness when the periodical attention to or replacement of small parts is regarded as unreliability. A week's net profit on the vessel would pay for a stock of these small trifles such as springs, valve cones, lamp coils, piston rings, &c., to keep the boat supplied for many years. Steam engineering practice is so settled in procedure that vessels have their regular overhaul every year or two years, and it would be considered very unpractical to run a vessel on any other system. But some owners when they have a motor vessel regard it as a sewing machine, and think there is something radically wrong when any part calls for attention, and they let three or four years go by without providing for a general overhaul.

Engineers.—With the numbers of men being demobilised from the Navy and Army, with experience in motor work, the fear of not finding suitable men should be dispelled. Small naval vessels with 40 brake horse-power to 80 brake horse-power hot-bulb oil engines have been numbered in hundreds. Of larger units, it is interesting to record that eight small monitors and a number of tankers for the Admiralty accounted for some two dozen engines, each of 320 brake horse-power, and a few of 160 brake horse-power and 120 brake horse-power, all of one make only. This means that in respect of this one firm's engines, many men will have obtained first-class experience on hot-bulb engines and become available as demobilisation proceeds.

Our ports, rivers and coastal waters are badly in need of oil-engined craft, and an unbiassed investigation of the question would relieve present congestion very appreciably.

The railway situation calls for more and more attention to coastwise traffic, and this traffic will become dominated by those who will lead a vigorous policy in the adoption of motor propulsion. The over-loyal adherents to the admittedly highly-developed and systemised steam practice, may find themselves heroic "die-hards," while their more alert competitors are absorbing their trade.

I am, yours truly,

R. A. Pelmore.

STANDARD SPINDLE NOSES FOR MILLING MACHINES.

To the Editor of Engineering.

Sir,—With reference to Messrs. Archdale's letter on page 548 of your issue for October 24, we suggest that an American or foreign standard for such an important detail as the spindle nose of a milling machine, should not be adopted by British firms, unless it can be shown that such standard has manifest advantages over any British standard that has been put forward. Other things being equal a British standard should have the preference, and it appears to us that there is very little to be said for the adoption of the American standard suggested by Messrs. Archdale, as against our own, which has been in use successfully for a very much longer period than the American standard. The standard in question is understood to be that recently adopted by the Cincinnati Milling Machine Company, and has not in any way been accepted as a standard in America, as is instanced by the fact that the Brown and Sharpe Manufacturing Company have just adopted a new standard for all their milling machines, which in essence is practically identical with the Herbert standard, consisting of a hardened conical nose and a hardened box clutch, which are the essential features of the Herbert standard.

Comparing the two standards it appears to us that the Cincinnati spindle nose has objections which are sufficiently serious to prevent its adoption as a standard in this country, and which may be summarised as follows:

1. The adoption of the design would show a lack of national spirit and of British initiative.

2. The application and removal of face cutters takes very much longer than with the Herbert nose, on account

of the time required to fit the cutter or adapter over the parallel collar on the spindle, and the time required to insert and tighten up the four screws by which the cutter is secured.

3. The threads in the holes in the spindle nose are likely to wear out by the repeated insertion and removal of the screws.

4. The loose keys are objectionable and likely to move about and become slack in time under the pressure of cutting, and the small cheese-head screws which secure them appear insufficient for the purpose. If the keys are made solid with the spindle this objection disappears, but the others remain.

5. The parallel fit is liable to become too slack in course of time after cutters have been applied and removed many times, the wear taking place, of course, both on spindle nose and in the recesses in the cutters or adapters.

6. When applying the cutter to a vertical milling machine, the fitting of the cutter to the spindle and holding it there while the four screws are inserted and tightened, is slow and inconvenient as compared with the Herbert standard, in which the cutter can be placed on the table, and the table simply raised or the spindle head lowered, the taper nose entering the cutter easily and centralising itself.

7. The design necessitates very large collars on the arbours, which thus become unduly expensive, or else loose driving collars on the arbours, which are not so good as solid collars.

The British Engineering Standards Association has not yet decided to standardise spindle noses, but if this work is undertaken, we consider it important that the advantages of our own and of any other established British standards that may exist, should be fully considered before adopting any new standards, either of British or foreign origin.

We may say that we shall be glad to furnish blue prints of the standard spindle noses to any firms of machine tool makers who are desirous of adopting them.

Yours faithfully,
(For Alfred Herbert, Limited),
P. V. Vernon, Director.

Coventry, October 30, 1919.

UNIVERSITY MATHEMATICS FOR ENGINEERS.

To the Editor of Engineering.

Sir,—On looking up, from curiosity, the treatment of hyperbolic functions in a number of elementary text-books, the writer found, on pages 247, 346 and 347 of J. W. Mellor's "Higher Mathematics" a "demonstration" that the argument of the hyperbolic functions is proportional to the corresponding arc of the hyperbola, in the course of which he writes:

$$\frac{1}{\sqrt{2x^2 - a^2}} \int_a^x \frac{\sqrt{2x^2 - a^2}}{\sqrt{x^2 - a^2}}\, dx = \int_a^x \frac{dx}{\sqrt{x^2 - a^2}} \quad !$$

Possibly the lecturers, to whom your correspondent Mr. Dunton refers, have copied it into their lecture notes.

The correction of this silly and apparently current blunder is the real subject-matter of Mr. Dunton's letters, and by itself does not go far towards the reform of mathematical teaching suggested by a title which, but for printing at the head of his letters, he ignores pretty completely.

In support of teaching engineers the elements of functions of a complex variable, one may quote Chrystal Alg. II, chapter xxix (the whole of which is commended to notice), paragraph 30: "When this point of view is taken the theory of circular and hyperbolic functions attains great analytical symmetry, for it becomes merely a branch of the general theory of the exponential function . . ." Chrystal further remarks that relations with the hyperbolic *arc* involve elliptic functions.

Another quotation, page 7 "Modern Analysis," Whittaker and Watson, runs: "The introduction of the complex member has led to many important developments in mathematics. Functions which, when real variables only are considered, appear as essentially distinct, are seen to be connected when complex variables are introduced; thus the circular functions are found to be expressible in terms of exponential functions . . ."

As an example:

$\int_0^x dx/(1 - x^2)$	$\int_0^x dx/(1 + x^2)$
	$= \frac{1}{2i}\int_0^{ix} d(ix)/[1 - (ix)^2]$
$= \frac{1}{2}\log[(1 + x)/(1 - x)]$	$= \frac{1}{2i}\log[(1 + ix)/(1 - ix)]$
$= \tanh^{-1} x$	$= \tan^{-1} x$
$= x + x^3/3 + x^5/5 + \ldots$	$= x - x^3/3 + x^5/5 - \ldots$
$0 < \lvert x \rvert < 1$	$0 < \lvert x \rvert \leqslant 1$

It will be noted that the substitution of ix for x in an integral power series of x suggests the classification of the terms according as $(i)^n$ has one or other of four possible values $\pm 1, \pm i$.

This may be compared with the effect of substituting $-x$ for x, which suggests the classification of the terms according as $(-1)^n$ has one or other of the two possible values ± 1.

The latter classification separates the sum of the terms into two sums which are respectively odd and even functions of x.

The former classification separates the sum of the terms into a "real" and an "imaginary" part according as i is not or is a factor, and each of these parts again into odd and even functions of x.

The introduction of the so-called imaginary unit i, or $\sqrt{-1}$, should scarcely be more difficult to the engineer than the introduction of negative quantities, and less so than that of irrationals.

"Real" and "imaginary" are unfortunate terms, and it is discreditable to teachers that they have not long since been replaced by really descriptive terms. In electrical engineering i may represent the unit of out-of-phase current, E.M.F., &c., and, in fact, Steinmetz has used the language of complex algebra to describe the whole range of alternating current phenomena.

In navigation, 1 mile north of the north pole has no physical meaning.

Thus, the so-called imaginary unit may represent a real physical quantity in one problem, and the so-called real positive unit may have no physical meaning in another problem. Again, a negative or fractional man is a physically unreal quantity, yet the corresponding symbols have their uses in statistical returns, independently of the possibility of their representing physical realities.

The student, and especially the engineer, should be at pains to strip the adjectives "real" and "imaginary" of their everyday meanings, and clothe them with their specialised meanings, which imply that certain symbols are subject to certain algebraic rules.

This concludes the present small contribution to reform in mathematical teaching for engineers, and others. In view of the criticism of Mr. Mellor, above, the writer signs in full.

I am, &c.,
London, October 22, 1919. A. R. Low.

THE CONTROL OF INDUSTRY.

To the Editor of Engineering.

Sir,—I should like to point out an inaccuracy in your leading article—"The Control of Industry"—in the current number of Engineering (October 31). On page 586, column 1, you state:—

"This is the essential weakness of the syndicalisation schemes which have been put forward in connection with the coal industry."

On page 578, column 2, it is stated:—

"That," Mr. Hodges said, "would be syndicalism, and I have as strong an objection to syndicalism, on account of its anti-social character, as I have to capitalism."

Mr. Hodges speaks as the miners' representative and as such is duly authorised to express their views. Most labour men reading your article would conclude that you were deliberately attempting to mislead your readers in order to bring discredit upon the miners. Therefore a correction should certainly be made.

Yours faithfully,
Charles F. Bennett.

10, Fairfield-road, Old Charlton, S.E. 7,
November 4, 1919.

[The article on page 586 had no specified relation whatever to the speech of Mr. Hodges quoted on page 578: it put forward general reasons, without reference to Mr. Hodges.—Ed. E.]

Motor Tractor Trials in India.—We learn from the Director of Agriculture at Nagpur, C.P., India, that a competitive trial of motor tractors and self-contained motor ploughs will be carried out on the Nagpur farm, C.P., India, in the beginning of January, 1920, at the time of the meeting of the Science Congress. Medals and prizes of 2,000 rupees will be given to successful competitors, implements being judged upon their construction, the quality and quantity of work done and their suitability for Indian commerce.

Personal.—It is announced that arrangements have been completed for the amalgamation of the business carried on by Mr. Robert W. Paul at New Southgate, London, with the Cambridge Scientific Instrument Company, Limited. Mr. Paul will join the board of directors and the manufacture of instruments will be continued both at Cambridge and at New Southgate. Until the end of the year the selling and manufacturing arrangements will be unchanged, but on January 1, 1920, the name of the company will be altered to the Cambridge and Paul Instrument Company, Limited, and as soon as possible the head office and showrooms transferred to London.

The late Mr. George Byland Roche.—We regret to have to record the death, which occurred on October 31, at his residence in Upper Norwood, of Mr. George Byland Roche, a member since May, 1875, of the Institution of Civil Engineers, and at one time the chief engineer of the London, Chatham and Dover Railway. Mr. Roche was 88 years of age. He served his pupilage in engineering from 1851 to 1853 with Mr. W. G. Owen, then resident engineer of the South Wales Railway, and was afterwards appointed engineer on the Great Western Railway during the construction of the Chepstow Bridge by Mr. I. K. Brunel. Then he was for two years assistant, and for seven years one of the district engineers on the South Wales Railway. In the 'sixties of last century, he was appointed resident engineer of the Sittingbourne and Sheerness Railway and became later general manager of the same system until it was absorbed, in 1870, by the London, Chatham and Dover Railway. He was on the staff of the latter railway for many years, being ultimately appointed its chief engineer.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Manufacturers are in an irritating position. The latest postal deliveries from Continental sources have brought a further influx of orders for machinery and heavy steel, much of which makers are unable to take on while production is so seriously crippled by the moulders' strike. Inquiries in representative quarters confirm the opinion that the moulders' strike, plus the serious defects of railway transport, is holding up a real revival in steel and machinery. Some of the smaller foundries have been compelled to follow the example of Messrs. Hadfields, Limited, and close down indefinitely. The number of men thus displaced who are ineligible for unemployment donation form a serious tax on their union funds. Though there are still weak patches in the crucible steel trade, a welcome feature is the improvement in the export demand for special steels, and particularly for high-speed steel, which has occupied an unsatisfactory position since the close of hostilities. This, in turn, has brought more business into the market for steel alloys. The new tungsten works are benefiting with the rest. Increased attention is being paid to motor steel and parts required for vehicle construction. Some of the rolling mills are so greatly taxed that they have decided to reinstitute the three-shift system and ensure continuous output. Motor lorry construction works are making record demands on steel producers. The moulders' strike has also turned the attention of the more enterprising firms to the emergency value of moulding machinery for large wheel centres, and it is probable that a good deal of this machinery will take the place of hand-moulding methods. Rolled and hammered mild steel finds a ready market. Quotations in raw material are principally in an upward direction. In finished iron, common bars maintain the official price of 22*l.* 10*s.*, but are difficult to obtain at that figure. Lincolnshire makers quote 8*l.* 17*s.* 6*d.* for basic, and 8*l.* 12*s.* 6*d.* for foundry. Derbyshire basic stands at 8*l.* 15*s.*, foundry at 9*l.* 2*s.* 6*d.* and forge at 8*l.* 10*s.* Steel billet makers have plenty of work on hand, but are compelled to restrict output because of the impossibility of finding an adequate railway tonnage. Bessemer acid are quoted at 19*l.* 2*s.* 6*d.*; Siemens acid at 19*l.* 12*s.* 6*d.*; hard basic at 16*l.* 10*s.*; and soft basic at 15*l.* 5*s.* The tonnage of American material consumed locally is only fractional. Drop-forging machinery for scissor blanks and small tools has proved highly successful, and its use is being extended in the cutlery trade.

South Yorkshire Coal Trade.—Collieries are kept fully employed on day-to-day commitments. There is a strong demand for best steam hards. Railway companies, blast furnaces and steel makers are pressing for increased deliveries to build up depleted reserves to the normal. Export trade is practically limited to bunkering coal. Big contract deliveries of cobbles, nuts and slacks have this week gone away to inland works. The house coal trade is carried on under difficulties. Supplies are not nearly sufficient to meet the demand for immediate consumption and winter stocking purposes. Added to this the wagon shortage makes it impossible to maintain a regular chain of supply. All qualities of coke find a ready market at maximum prices. Quotations: Best branch handpicked, 33*s.* to 34*s.*; Barnsley best Silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Though home consumption of Cleveland foundry pig-iron has been checked by the continued strike at the iron foundries, the scarcity of that quality is still so pronounced that producers are altogether unable to deal with needs. They are very considerably in arrears with deliveries, and until output is increased and more trucks are available there is no prospect of the arrears being overtaken. There are now plenty of export licences to be had, but the purchase of iron for shipment is very difficult. Demand on Continental account is very heavy notwithstanding that there is now some cheap German iron on offer. Forge pig-iron is quite abundant, but makers are not disposed to reduce the price. For home consumption, No. 1 Cleveland pig is 164*s.*, No. 3 g.m.b. and No. 4 foundry stand at 160*s.*, and No. 4 forge ranges from 157*s.* to 160*s.*, according to brand. Export prices are 5*s.* above the foregoing quotations.

Hematite Iron.—East Coast hematite is still in ample supply, but after recent rather heavy sales is not offered quite so freely. Further substantial Continental inquiries are in the market. Nos. 1, 2 and 3 are 200*s.* for home use, and 205*s.* for shipment abroad, and No. 1 is 202*s.* 6*d.* for home purposes and 207*s.* 6*d.* for export.

Coke.—Coke keeps very strong. Heavy local needs are not easily satisfied, and parcels in the market readily realise full rates. Thus average blast-furnace quality commands 48*s.* at the ovens and low phosphorus sort makes 49*s.* 6*d.* at the ovens.

Foreign Ores.—One or two principals of important ore firms have been here this week, but their visit does not appear to have resulted in new business. Consumers continue to carry considerable stocks, and have substantial contracts made, whilst sellers are a good deal behind with deliveries, so that new transactions of any

moment seem hardly likely to occur. A freight fixture, Bilbao-Middlesbrough, is reported at 24*s.*, and the price of best rubio is stated to be no more than 52*s.* 6*d.* c.i.f. Tees.

Manufactured Iron and Steel.—Producers of manufactured iron and steel report their plant fully employed in the endeavour to overtake back work. Substantial orders for home and abroad are in the market, demand being heaviest for shipbuilding requisites and railway material. Values, all round, are well maintained. Export quotations are still matter of individual negotiation, but may be given as a little above the following, which govern the home trade:—Common iron bars, 22*l.*; marked bars, 25*l.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel boiler plates, 21*l.* 10*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; heavy sections of steel rails, 16*l.* 10*s.*; and galvanised sheets, 35*l.*

Shipments of Iron and Steel.—The total shipments of iron and steel from Middlesbrough last month were the lowest since July, when they were returned at 38,571 tons, and fell below the monthly average for the year, amounting to 39,988 tons, composed of 20,541 tons of pig-iron, and 19,447 tons of finished iron and steel, as against the previous month's total of 42,563 tons, composed of 21,893 tons of pig-iron and 20,670 tons of manufactured iron and steel. Of the pig-iron shipped in October, Belgium received 7,119 tons; America, 2,000 tons; Japan, 2,000 tons; Holland, 1,515 tons; Norway, 1,459 tons; Sweden, 1,144 tons; Italy, 588 tons; Denmark, 175 tons; whilst of manufactured iron and steel despatched last month India took 4,409 tons; Holland, 2,109 tons; China, 1,456 tons; Japan, 1,239 tons; Belgium, 597 tons; and Egypt, 569 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Markets.—Conditions generally on the coal market show no change to those governing business a week ago. There has been a substantial improvement in the tonnage position, owing to a diversion of shipping to this district as a consequence of the strike of United States miners, but collieries have been unable to benefit from this factor because of the slowness of loading operations and the delay experienced in returning empty wagons to the pits. As a result of this many collieries are awkwardly placed and have difficulty in keeping the pits working regularly, wh le buyers able to arrange quick shipment are ready to make sacrifices in order to secure a quick release of empties. The leading descriptions of large are readily available on the basis of 70*s.*, with best steam smalls round 52*s.* 6*d.* and concessions of 2*s.* 6*d.* possible for spot loading. Forward business is quiet, as sellers are reluctant to complete transactions on the basis of current levels, and for loading towards the end of the month ask round about 80*s.* for the better quality large coals and 60*s.* for best smalls; buyers are not disposed to concede these prices, and therefore actual dealings are restricted notwithstanding a good inquiry. Exports of coal from South Wales last week totalled 302,256 tons, of which 197,885 tons were shipped from Cardiff, 38,993 tons from Newport, 31,072 tons from Swansea and 34,306 tons from Port Talbot. The future of the coal export trade and expected early de-control was considered by a general meeting of exporters yesterday. The meeting was of a consultative character and was the outcome of a discussion in London last week with the Board of Trade. The object of the conference was to consult the general body of exporters so as to ascertain their views in respect to the various questions likely to arise. During the discussion reference was made to a proposal on the part of French buyers to appoint French buying agents in this country, which would mean the elimination of competition in the coal trade. The proposal was very strongly deprecated, though it was pointed out that the matter was in a tentative stage.

2,000,000*l.* *Shipping Deal.*—It is reported that Messrs. Edwards, Sons and Co., Cardiff, managers of the Western Counties Shipping Company, Limited, have acquired the Moor Line, Limited, managed by Messrs. Walter Runciman and Co., Limited, Newcastle-on-Tyne. The deal, which means the transfer of 13 steamers aggregating about 65,229 tons, involves about 2,000,000*l.* Messrs. Edwards, Sons and Co. will, with their newly acquired fleet, have the control of 17 steamers of a total carrying capacity approximating 88,000 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—In the Scotch steel trade there has been little change during the week as the trouble with the bricklayers has not yet ended and business is being much hampered. Supplies of plates are not forthcoming and consumers of steel are feeling the pinch, and the outlook is far from satisfactory. There is plenty of work to do, and inquiries are on a good scale, but delivery cannot be guaranteed, with the result that some business is passing to other areas. Departments not affected by the strike are all busy and in the case of black sheets the demand is active and pressing. Home users are taking in large deliveries of the heavier gauges, and good inquiries are in the market for export lots. Galvanised sheets are finding a good outlet despite the high price prevailing, and satisfactory bookings are reported. Sectional material is unchanged.

Malleable Iron Trade.—Active conditions are general in the malleable iron trade of the West of Scotland, and the demand from home consumers is on a large scale. Rivet makers being busy, a large amount of iron is in request by them. The export business is of little account at the present time because of the pressing demand for home requirements. Order books are very well filled, and prices are without change.

Scotch Pig-Iron Trade.—In the Scotch pig-iron trade there are signs of improvement and rather more business is passing. The output is not yet satisfactory, but the demand for hematites and foundry iron is very small at present owing to the strikes of moulders and steel-works bricklayers. The best qualities of pig-iron continue somewhat scarce, but lower grades are more plentiful. Export orders are improving, and as more tonnage becomes available the output in this direction will get better, as some good inquiries are again in the market. Prices all round are very firm with no signs of weakening.

Scotch Shipbuilding.—The Scotch shipbuilding returns for new tonnage launched, during the past month, are rather less than what was anticipated, and the total is under the average for the year to date. There has been no actual labour trouble in the yards, but the railway strike and unrest amongst other trades have all had their effect on supplies, and the difficulties with regard to deliveries have helped to keep back operations. The smallness of the output for October has been disappointing considering the fullness of order books, and it is now well nigh impossible for this year to come within measurable distance of the previous best. For the past month the totals were as follow:—

	Vessels.	Tons.
The Clyde	21	37,294
The Forth	3	3,797
The Tay	1	2,022
The Dee	2	194
Total	27	43,307

The Clyde output for the year to date is now 227 vessels, making 454,106 tons, which is quite a good figure, but is considerably lower than what was anticipated, and is more than 105,000 tons under the year 1913, when the figure was 559,834 tons. For the ten months the following are the totals for the different districts in Scotland:—

	Vessels.	Tons.
The Clyde	227	454,106
The Forth	26	40,908
The Tay	11	15,390
The Dee	40	9,195
Total	304	519,599

New contracts reported during the past month were few, but order books are well filled.

CONTRACTS.—Messrs. Clayton and Shuttleworth, Limited, have recently secured a very important order for Pullman cars, which will be constructed in their rolling-stock department, at Abbey Works, Lincoln. In addition to this order, they have on hand other very important contracts for rolling-stock with the Indian State Railways, and certain British railway companies.—Messrs. Sterns Ltd., Royal London House, Finsbury Square, London, E.C. 2, state that they are now in a position to offer deliveries of Genuine Russian No. 1 Engine Oil.

THE BRITISH ROPEWAY ENGINEERING COMPANY, LIMITED.—In our issue of October 31, page 599 *ante*, we noticed a catalogue just issued by this company, and in this notice referred to them as "a now all-British company which acquired Bleichert's business." We now learn that the company was registered on September 3, 1915, and that the only persons who have been connected with the firm, either as shareholders or directors, have at all times been, and are still, natural-born British subjects and men who are well known in the engineering world. Our notice may have suggested that at one time this company was not an all-British company, and we regret that any such inference was possible from what we wrote.

INSTITUTE OF MARINE ENGINEERS.—The first dinner held since the outbreak of war, of the Institute of Marine Engineers, proved highly successful, the attendance being probably a record. Lord Weir, the president, occupied the chair, and amongst the guests were Sir Eric Geddes (Minister of Transport) and Sir Auckland Geddes (President of the Board of Trade). The speeches were all highly complimentary, and deservedly so, of the work done by marine engineers, particularly in the mercantile service during the war, and also in connection with the construction of war material. A feature was the strong commendation of the internal-combustion engine, but there was a tendency to expect too much from this prime mover in its present state of development. Research, however, was strongly commended.

SWITZERLAND AND AMERICAN TRADE.—A Commission composed of representatives of the Southern American Congress (which has its headquarters at Washington), and including a special representative from the Department of Commerce in Washington, will shortly visit Basle, says *The Board of Trade Journal*. The Commission is at present visiting various Continental States with the object of establishing mutual financial and commercial relations between the United States of America and those States. As regards imports into Switzerland, the members of the Mission represent, among others, producers of cotton, iron, timber, coal, tobacco and vegetable oils, and special interest is being taken in all export industries, particularly the manufacture of silk ribbons, chemical products, boots and shoes, and watches and clocks.

NOTICES OF MEETINGS.

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, November 8, the Second Lecture of Session 1919–20 will be given in the Assembly Room of the Cycling Club, Cavendish-street, by Mr. Sam Gledhill, A.M.I.M.E., of Halifax. Subject: "Drilling Machines, Drilling and Twist Drills, with a Treatise on Workshop Practice as Affected by the Foregoing." Illustrated with lantern slides. Chair to be taken at 6.30 p.m. by Mr. Ellis Foster (the president).

THE SURVEYORS' INSTITUTION.—Monday, November 10, when the president, Mr. Andrew Young, will deliver an Opening Address. The chair will be taken at 8 p.m.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, November 11, at 7.15 p.m., at the Neville Hall, Neville-street, Newcastle-on-Tyne. Paper on "Electric Power Distribution," by Mr. L. C. Grant.

THE INSTITUTION OF ELECTRICAL ENGINEERS (SCOTTISH CENTRE).—Tuesday, November 11, at 7.30 p.m., the first ordinary meeting of the twentieth session will be held in the Rooms, 207, Bath-street, Glasgow, when the chairman, Mr. W. B. Hird, will deliver his Inaugural Address. Students' Section.—November 14, at 7.30 p.m., the Opening Address for the session will be delivered by Mr. F. H. Whysall, chairman, in Room 149 The Royal Technical College, Glasgow. It is hoped there will be a large attendance at this meeting, to restart the section, elect a committee, and arrange a programme.

THE ROYAL AERONAUTICAL SOCIETY.—Wednesday, November 12, at the Royal Society of Arts, John-street, Adelphi, at 8 p.m., a lecture will be delivered by Dr. Charles Atkin Swan, L.R.C.P., M.R.C.S., M.B., Ch.M., on "Some Physical and Psychical Effects of Altitude." The chair will be taken by Sir W. Arbuthnot Lane, Bart., F.R.C.S. There will be a discussion after the lecture.

THE INSTITUTION OF BRITISH FOUNDRYMEN.—Thursday, November 13, at 8 p.m., at the Cannon-street Hotel, when Mr. A. R. Bartlett will give his paper on "The Core Floor, and Some Essentials in Connection."

THE ROYAL SANITARY INSTITUTE.—Friday, November 14, at 7 p.m., in the Town Hall, Bootle, when a discussion will take place on "Reconstruction of the Public Health Services." It will be opened by Mr. E. W. Hope, O.B.E., D.Sc., M.D., Medical Officer of Health, Liverpool. The chair will be taken by Sir Henry Tanner, C.B., I.S.O., F.R.I.B.A., chairman of the Council.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Saturday, November 15, at 3 p.m., at the Danum Hotel, Doncaster, when the following paper will be read: "Notes on the Introduction and Delivery of Coke Oven Gas to Sheffield," by Mr. J. H. W. Laverick, and the paper on "The Permeability of Coal to Gases—Part II," by Mr. J. Ivon Graham, B.A., M.Sc., will be open for discussion.

INSTITUTION OF NAVAL ARCHITECTS.—The date for the opening of the next annual meetings of the Institution will fall on Wednesday, March 24, 1920. The council will be pleased to consider papers on subjects relating to naval architecture or marine engineering. Such offers (or suggestions for papers on matters of interest to the Institution) should, if possible, be sent in by the close of the year.

PUBLICATIONS OF THE BRITISH ENGINEERING STANDARDS ASSOCIATION.—Copies of four new standard specifications, all of which are issued at the nominal price of 1*s.* 2*d.* post free, have just been received from the British Engineering Standards Association. The first of these, No. 81, relates to current transformers and potential transformers for use with electrical measuring instruments. Limits of error for ratio of phase angle are specified, and high-pressure tests, ratios of transformation, and rated outputs are also dealt with. Two appendices relate to the use of transformers in general and with electricity meters, and another deals with single-turn current transformers. Specification No. 89, now issued, deals with ammeters, voltmeters, wattmeters, frequency meters and power-factor meters of the indicating type, and supersedes specification No. 49, issued in 1908, which dealt with ammeters and voltmeters only. In addition to the requirements in regard to accuracy, the specification includes a number of definitions, clauses relating to types of enclosure, scales, marking polarity of terminals, insulation, shunts, &c. Somewhat similar matter with regard to recording ammeters, voltmeters and wattmeters is contained in a separate specification, No. 90, now issued for the first time. Clauses relating to chart ruling, chart speed, and other points in connection with the design of recording instruments are also included in this specification. The remaining specification, No. 107, is devoted to standard rolled sections for magnet steel, and includes a symmetrical series of 60 sections for general purposes. It is recommended that only 34 of these sections should be employed as a rule, and that the remaining 26 sections be used for special purposes where it is impossible to employ the others. A supplementary list of 10 special sections for ignition magnetos is also included. The specifications can be obtained from Messrs. Crosby, Lockwood and Son, 7, Stationers' Hall Court, Ludgate Hill, London, E.C. 4, or from the offices of the Association, at 28, Victoria-street, London, S.W. 1.

ENFIELD-ALLDAY 10-H.P. MOTOR CAR WITH AIR-COOLED ENGINE.

CONSTRUCTED BY MESSRS. ENFIELD-ALLDAY MOTOR COMPANY, LIMITED, BIRMINGHAM.

(*For Description, see Page* 626.)

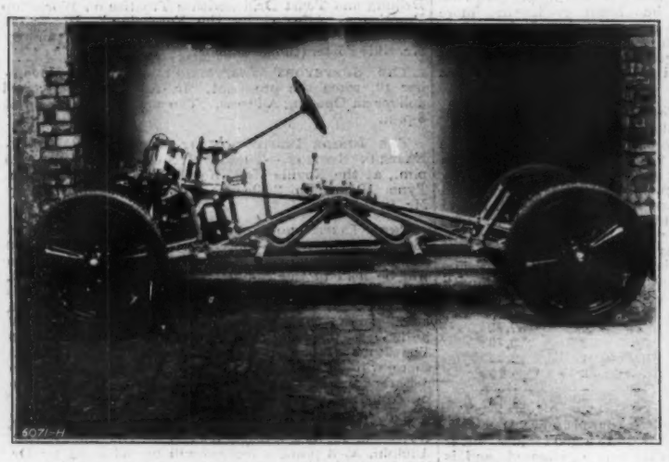


FIG. 1. SIDE VIEW OF CHASSIS.

FIG. 2. REAR END OF CHASSIS SHOWING GEAR-BOX SUPPORT.

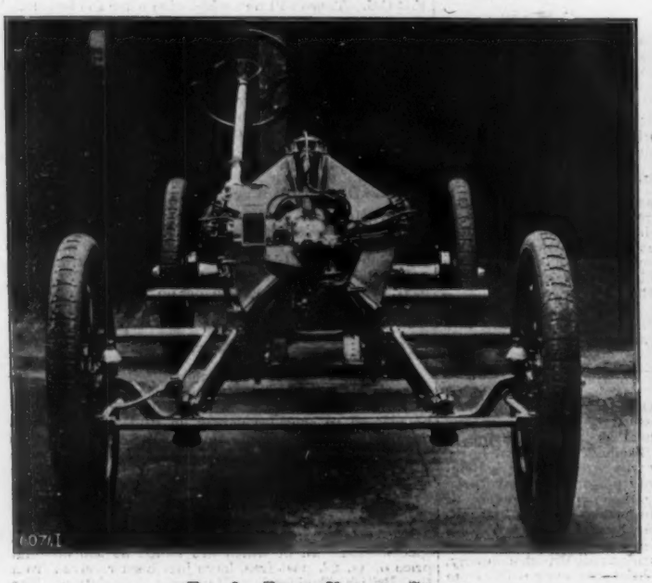


FIG. 3. FRONT VIEW OF CHASSIS.

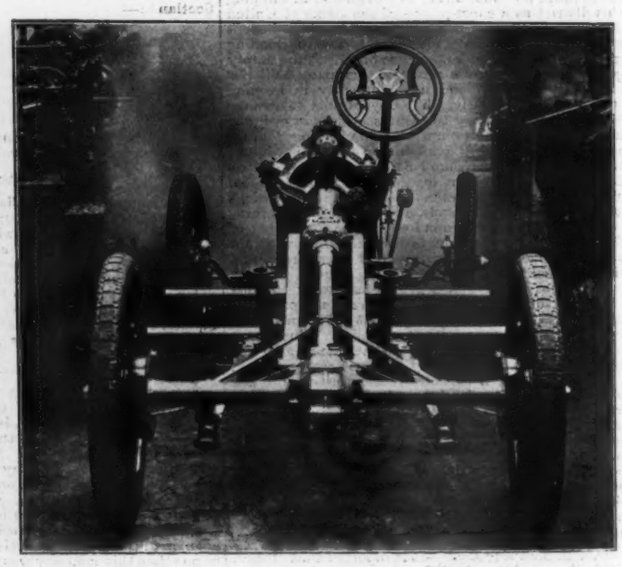


FIG. 4. REAR VIEW OF CHASSIS.

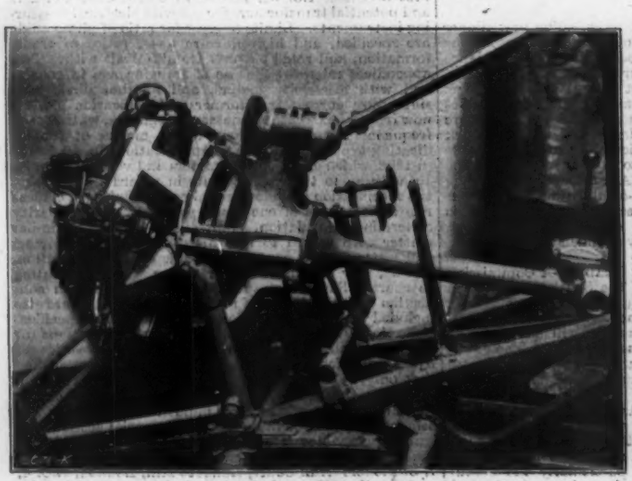


FIG. 5 VIEW OF ENGINE: NEAR SIDE.

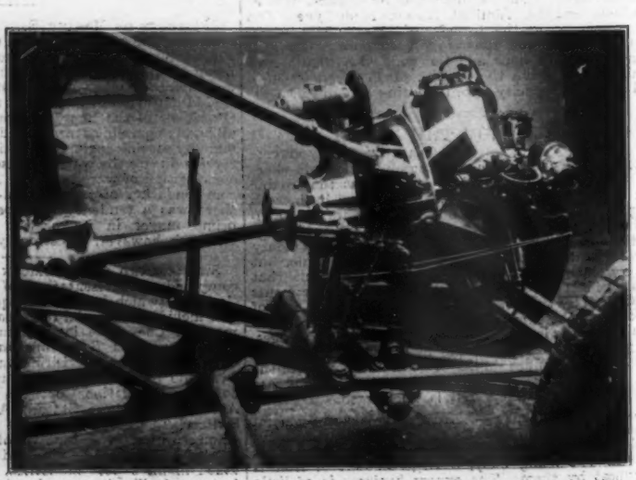
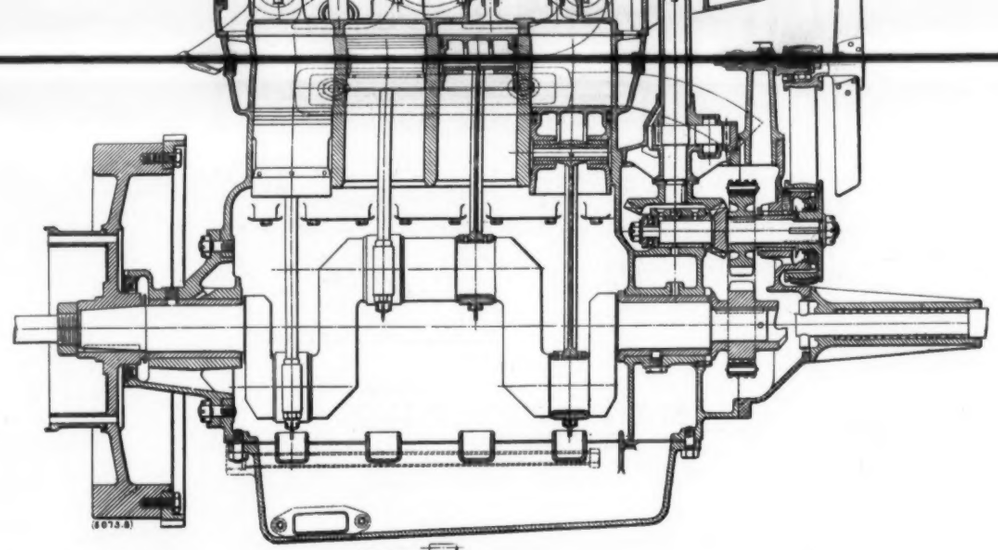


FIG. 6. VIEW OF ENGINE: OFF SIDE.



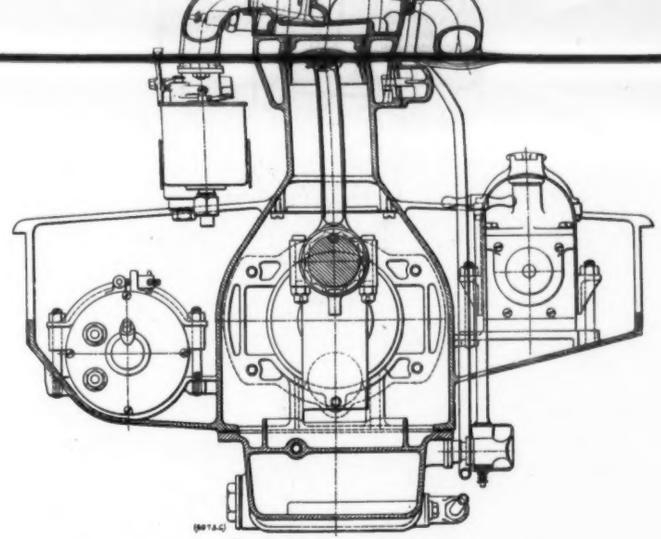


Fig. 5.

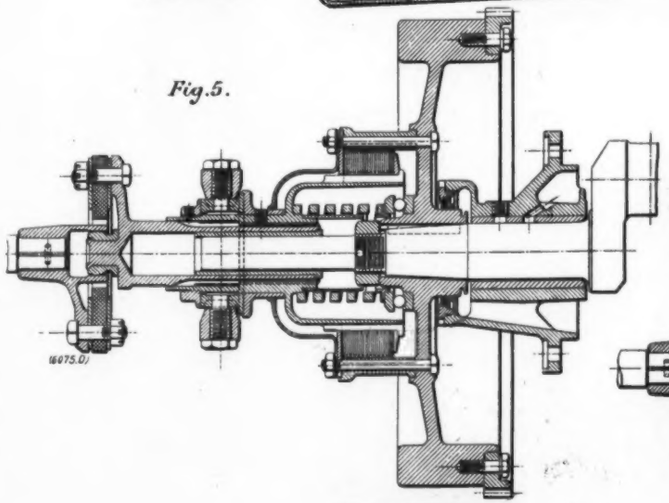


Fig. 6.

Fig. 7.
SECTION OF SPRING PLUNGER

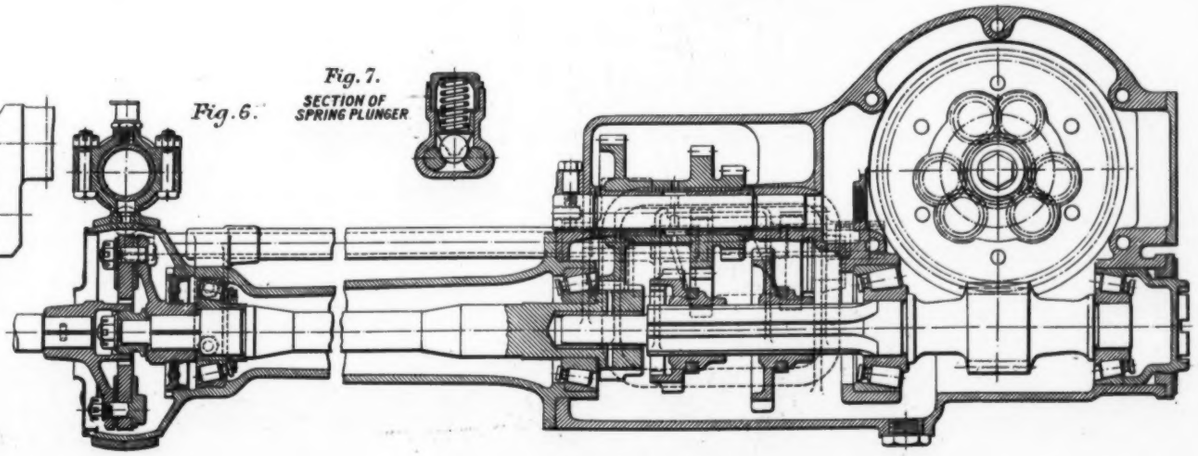
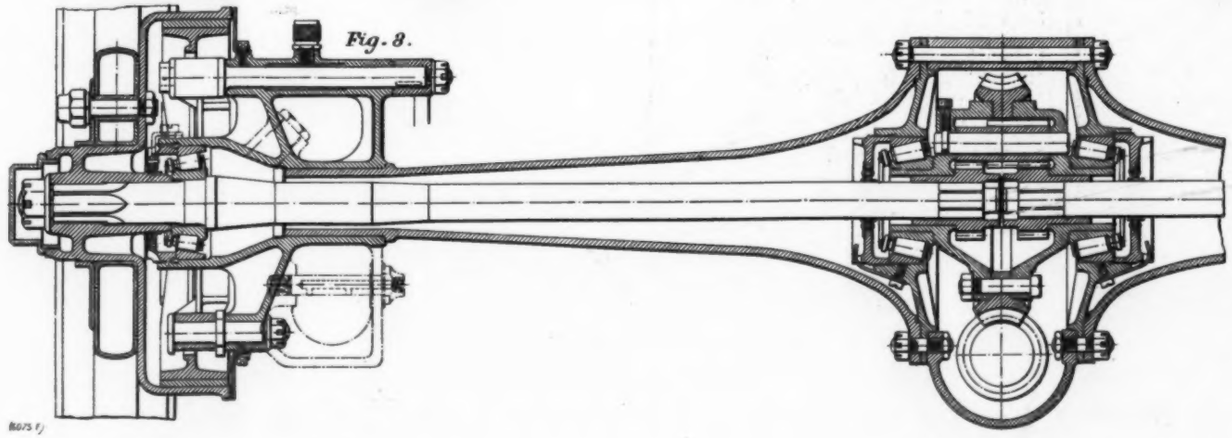


Fig. 8.



10-H.P. WOLSELEY MOTOR CAR AT THE OLYMPIA SHOW.

CONSTRUCTED BY MESSRS. WOLSELEY MOTORS, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Page* 606.)

Fig. 1.

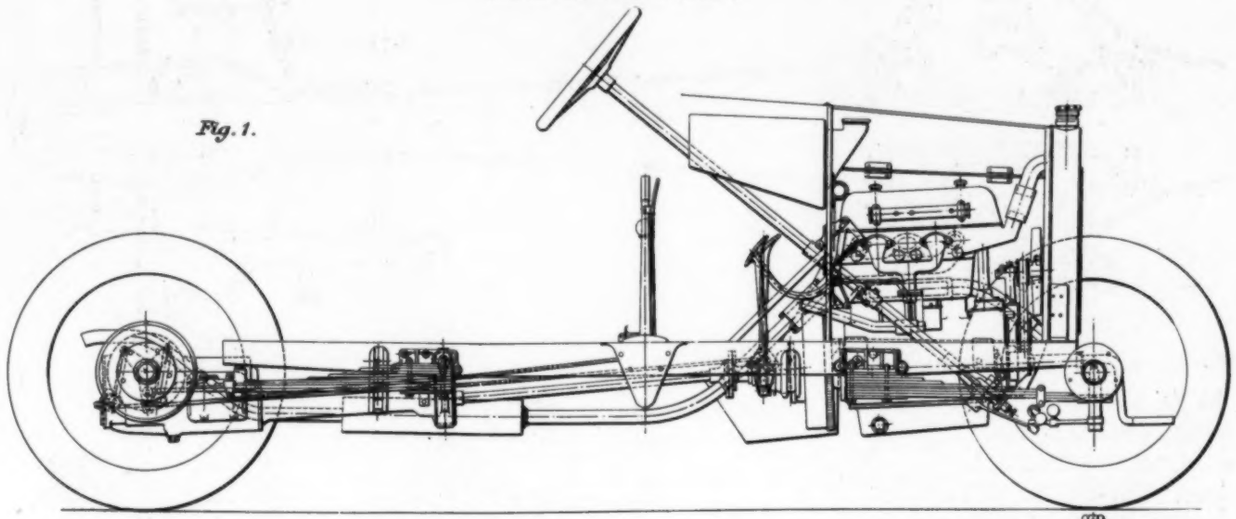


Fig. 2.

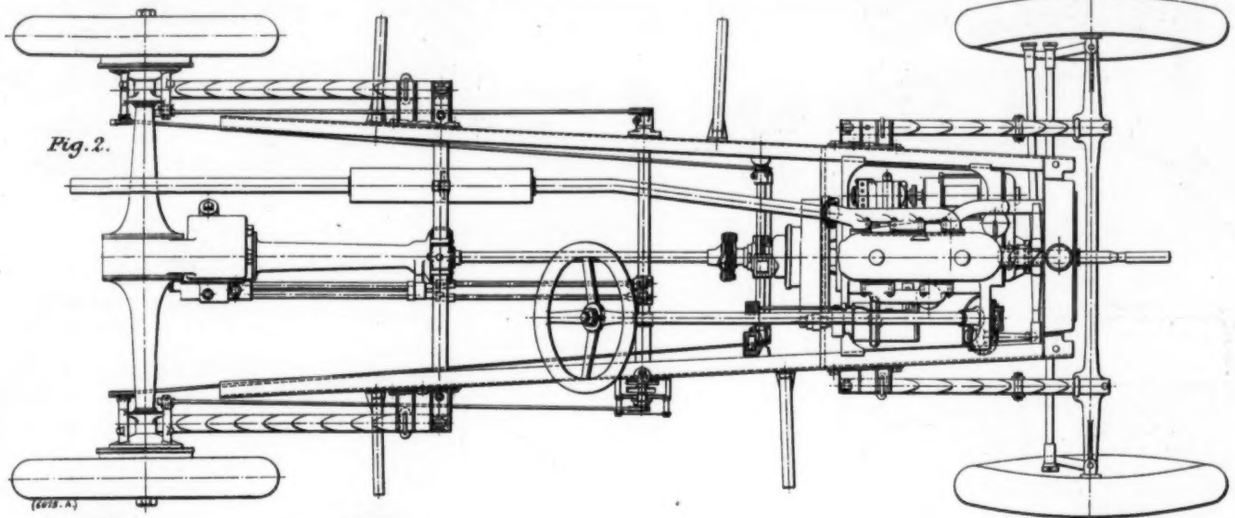


Fig. 3.

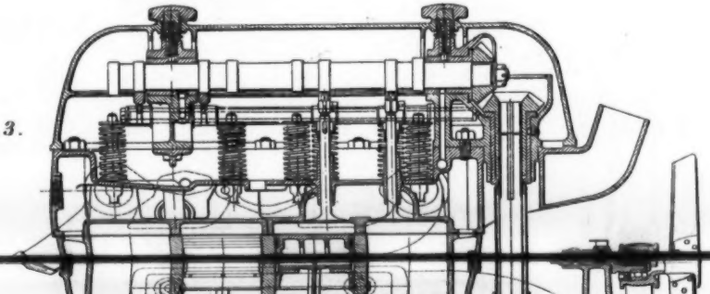
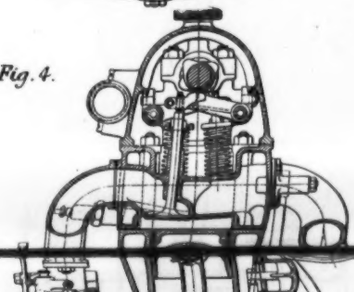


Fig. 4.



AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaughnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long-street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue.
For Advertisements, J. S Allan, 18, Broadway, New York.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2 9 0
For Canada—	
Thin paper copies	£2 5 0
Thick ,, ,,	£2 9 6
For all other places abroad—	
Thin paper copies	£2 9 6
Thick ,, ,,	£2 14 0

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON,

TELEPHONE NUMBERS—3663 and 8508 GERRARD.

CONTENTS.

	PAGE
A Complete Theory of the Screw Propeller Working in Air	601
Hell Gate Bridge, New York (*Illus.*)	603
Wolseley Cars at Olympia (*Illus.*)	606
20-H.P. Austin Car at Olympia (*Illus.*)	610
Industrial Notes	611
The Solidification of Metals from the Liquid State (*Illus.*)	612
Saving in Fuel Bill on Oil-Engined Vessels (*Illus.*)	615
Standard Spindle Noses for Milling Machines	615
University Mathematics for Engineers	615
The Control of Industry	616
Notes from South Yorkshire	616
Notes from Cleveland and the Northern Counties	616
Notes from the North	617
Notes from the South-West	617
Notices of Meetings	617
Intensive Production and Accident Risks	619
Some Present - Day Problems	620
The International Labour Congress	620
Notes	621
The Motor Car Show at Olympia	622
Literature	623
Books Received	624
Catalogues	624
Diagrams of Three Months' Fluctuations in the Prices of Metals	625
Explosion of a Cast Iron Tank at Hull	626
Enfield-Allday 10 - H.P. Motor Car at the Olympia Show (*Illus.*)	625
The Institution of Civil Engineers—Presidential Address	626
Synthetic Cast Iron (*Illus.*)	632
ENGINEERING Patent Record (*Illus.*)	635

With a Two-Page Plate of the 10-H.P. WOLSELEY MOTOR CAR AT THE OLYMPIA SHOW.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 617.

ENGINEERING.

FRIDAY, NOVEMBER 7, 1919.

INTENSIVE PRODUCTION AND ACCIDENT RISKS.

THE year 1918 was notoriously one of intense industrial activity, although the production did not to any great extent add to the material assets of the nation. An enormous output was derived from workshops staffed by dilutees and operated under conditions often of considerable risk. Moreover, even in the case of factories not engaged in work of an intrinsically dangerous character, the safety of the operatives was in many cases sensibly diminished by the lighting restrictions. In view of the combined effects of the inexperience of many of the workers, the large numbers engaged in producing explosives and poison gases, and the enhanced risk due to restricted lighting, it would not have been surprising if the accident roll had attained abnormal dimensions. This, however, has not been the case. Indeed, even before the war, many important firms had inaugurated a "Safety first movement," and notably reduced thereby their casualty list. The policy thus commenced received a great extension, when the introduction of large numbers of dilutees directed special attention to the need for correspondingly greater precautions against accident. This solicitude for the welfare of the workers was very general, and accounts for the fact that notwithstanding the highly unfavourable conditions under which operations had to be conducted, the number of accidents recorded was in some areas actually less than in 1914. This was notably the case in the Midlands where, according to the official report* just issued, the total number of accidents reported was 35,706 in 1914, 29,556 in 1917 and 28,699 in 1918. This reduction is remarkable not only in view of the greater output, but also because there has been a steady tendency of late to class and report as accidents, mishaps which in former years would have been regarded as insignificant incidents. In the old days an apprentice fitter who got a fragment of metal in his eye commonly went for aid to his nearest neighbour or to the "shop specialist," who, with the aid of a large pin or the blade of a penknife, removed the intruder, and nothing further was heard of the matter. From certain official reports it appears that such incidents are now frequently classed as accidents, so that a difficulty arises in comparing records for different years or different countries. For example, according to official figures there were in pre-war conditions fewer accidents to railway employees in Germany than here, but the number of fatal accidents to the staff was notably higher on the German than on the British lines. It is therefore obvious that our railway companies were including in their reports mishaps which on the German State lines would be regarded as incidents too trivial to be noted.

Similarly, although as stated the total number of casualties of all kinds in British factories was last year remarkably low, the proportion of serious or fatal accidents was higher than in pre-war times. There were 1,579 fatal accidents out of a total of about 164,000. Of this total about two-thirds were of a kind which would not be affected by regulations for fencing or other safeguards, and of the residue only a small fraction were attributable to the lack of these. In fact, the inspectors report that many firms are going beyond the statutory requirements in such matters, and have shown much initiative and ingenuity in devising new precautions against accident. The great majority of the accidents have arisen from the recklessness or ignorance of the operatives. As one of the inspectors reports, many men disdain to think too much of their personal safety, and consider the use of a safeguard as a sign of timidity. Another inspector states that more accidents are due to defective training and absence of discipline than to any other cause. One firm, for example, had for years employed a safety inspector to see that guards were properly maintained, but this official had, owing to the exigencies of the war, to be withdrawn. A visit made to the works a few months subsequently showed that the fencing had got into a most unsatisfactory condition, and guards had been lost, displaced or destroyed in the most wholesale fashion.

A great deal can be effected in the matter of diminishing industrial risks by enlisting the co-operation of the men. To this end some firms have formed safety committees consisting of representatives appointed in part by the management and elected in part by the men. It has been found best that the elected representatives should serve for a term of six months only, and should not be eligible for re-election for the succeeding twelve months. In this way a greater number of the men are directly associated with the movement. Such a committee inquires into and reports on all accidents, and appoints delegates who make periodical inspections of the different departments in conjunction with the management. By this and further arrangements of a similar character one firm succeeded in reducing the number of accidents by 50 per cent. in the course of a single year. In another case a similar committee actually suspended from employment negligent operatives, with the warning that a repetition of the offence would involve dismissal.

The admission of dilutees has, it is reported, done much to increase the use of appliances which incidentally lessen the danger to machinists. Jigs were introduced extensively into certain wood-working factories, and enabled the work to be done without necessitating the operative's hands coming into the immediate vicinity of the cutters. Even in the case of metal work, the use of jigs diminishes risks, and a similar end has been obtained by fitting automatic feeds to power presses and conveyors to feed rolls. Taken in all, this section of the report shows that progressive firms have given much thought to reducing the dangers associated with most industrial operations. Of course, in the nature of things, pioneers must necessarily be a minority of any community, and legislation is ultimately necessary to compel the laggards to close up to the van. These laggards are for the most part found amongst the smaller and more struggling firms.

It must also be recognised that the policy of "safety first" is practicable only when an industry has reached a certain stage of development. It would, for instance, have been impossible five years ago to impose official rules for the strength of aeroplanes. Indeed, the history of the "safety first" movement is noteworthy in this regard, as it originated on the American railways during the last score of years or so. In their early days American railways were notoriously dangerous, but the American people had to choose between having no railways or cheap and correspondingly dangerous undertakings. They very wisely elected for the latter alternative, and in so doing hastened the development of their country by fifty or one hundred years. It has now become possible to elevate tracks, abolish level crossings and establish block signalling. Had such safety provisions been insisted on in the early years, thousands of lives might have been saved, but millions of citizens would never have come into being. "You take my life when you do take the means whereby I live," says Shylock. An insistence on British standards of safety during the early days of American railway undertakings would have deprived myriads of potential citizens of the States of the means whereby they might live. The imposition of impracticably high standards of safety in industrial undertakings may, in fact, rob the State of more lives than an abnormally high accident roll. As we were the pioneers in practically all modern methods of production, so have we

* *Annual Report of the Chief Inspector of Factories and Workshops for the year* 1918. [Cd. 349.] H.M. Stationery Office. Price 9d.

been in advance of all other countries in the matter of reducing industrial risks; but the process has rightly been tentative, and betterments have been effected step by step.

Amongst the dangers, risks of poisoning by lead, phosphorus, arsenic, and mercury, were at one time very rife. Thus, in 1900, there were 1,058 cases of lead poisoning. This was reduced to one-half in 1914, and has now fallen to 144, but the output in 1918 was only about 60 per cent. of the normal. On the other hand, war industries introduced new forms of poisoning. The use of tetra-chlorethane in a dope for aeroplane wings led to many cases of toxic jaundice, and experiments were immediately undertaken to discover a less dangerous substitute. These proved successful, and the inspector is able to report that no cases occurred last year due to dope, and only 34 arose from the manufacture of T.N.T. In the previous year there were 189 cases of T.N.T. poisoning: 44 were fatal. This substance, until its production was undertaken in large quantities, was not even classed as a poison, and it is much to the credit of those concerned that the casualty rate should have been so rapidly reduced. The manufacture of poison gases for chemical warfare led to many casualties. Some were due to arsenic trichloride and very many to mustard gas, which was responsible for 1,400 cases during the six months from June to December. Fortunately, of these only 3 proved fatal. The large number of cases is attributed to the necessity of proceeding with the manufacture before the works were fully prepared.

One effect of the introduction of female labour has been to impress on many firms the need for improvements on their methods of handling materials. On the average, a woman's physical strength appears to be about 70 per cent. that of a man, and weights which he can handle without over-strain proved in nearly all cases too much for women. Lifting and conveying plant had accordingly to be extensively introduced, with the result that in many cases the woman attained a higher output than the man she replaced. Mention is made in the report of the remarkable hydraulic lathes and other appliances introduced by a firm in the southern district, in a shop run entirely by girl labour. The work consisted in the production of 9·2-in. shells, and the output was, we understand, nearly twice as much as in a Sheffield shop, run with an equal number of skilled machinists, but equipped with ordinary lathes.

This is only one instance of the failure of British firms in the past to realise the importance of motion study, and the consequent elimination of unnecessary exertions. The principles are, however, gradually making their way, and the report under review records many instances, showing that the principles first formulated by Mr. Taylor are at length finding a more general application. Thus, in boxing biscuits, one firm has introduced the plan of putting the tin to be filled below an opening in the table, so that instead of the biscuits having to be lifted the operative can simply slide them into the packet. In steel works, the report states, the use of furnace-charging machines is now becoming nearly universal, and the electromagnet crane by which steel plates and billets can be lifted and transported, with a minimum of labour and danger, is also being widely adopted.

The section of the report dealing with hours of labour has a special interest at the present time. Many firms assert that output is directly proportional to the time worked. No doubt this is true if a comparison be made shortly after a change in shop hours. Time is necessary for the workman to adjust his customary gait to the new conditions; but many instances are given in the report, in which output is now as high or higher with shorter hours than it was before the change. Thus one firm manufacturing textile machinery on a large scale reduced their hours from 53 to 48 per week. They report that the moulders on practically all jobs make the same number of boxes per blow as formerly, and machinists on piece-work, with but one or two exceptions, have earned the same wages as before. One great gain has been the improvement in the matter of time-keeping. With the 53-hour week, 17 per cent. of the men arrived late; the corresponding figure for the 48-hour week is less than 1½ per cent.

This, indeed, has been the general experience, and goes to show that the longer hours may have been in excess of what the weaker operatives could stand. Moreover, it has frequently been noted that even where the men did not lose time, the output in the first quarter of the day was often much below normal. It would appear from the report that this is true even as regards the textile trades, where the work is wholly done by machines and output is less dependent on the vigour of the operative than in many other industries. In the engineering trades the output in the first quarter has in some cases been found to be 30 per cent. to 40 per cent. below normal.

One effect of shorter hours should be to increase the utility of evening classes. These have been of great service to clever lads in the past, but with a long factory day, the strain was over much for many. The shorter working day should accordingly lead to substantial increase in the number of students and in the average standard of attainment.

SOME PRESENT-DAY PROBLEMS.

Life has been aptly described as the continuous adjustment of the organism to its environment, and the definition may undoubtedly be extended from the individual to the organisation. Our national records are rife with instances of societies or corporations which have proved too inert to move with the times, and have ultimately utterly outlived their utility. It is a healthy sign, therefore, that several of our leading technical societies are earnestly engaged in studying proposals for enlarging their field of usefulness and increasing the attractions they already offer to prospective members. One of the most popular of the suggestions made to this end, is the establishment of local associations affiliated to the parent body. Provincial and Colonial members would thus, it is claimed, have greater opportunities for social intercourse, the promotion of which between its members is admittedly one of the proper functions of a technical society. In his interesting address delivered to the Institution of Civil Engineers on Tuesday last, Sir Joseph Purser Griffith made a strong plea in favour of this policy. As in most other mundane matters, however, the arguments are not wholly on one side. All our great societies have many members resident in regions where engineers are few and far between, and in which it would accordingly be impossible to establish a successful branch of the parent body. It is to the interest of such members, and they are many, that the surplus funds of the Institution should be devoted to the continuous and systematic improvement of the society's publications rather than to the formation of local associations.

In another part of his address the president drew attention to the fact, that though Ireland is a small country, Irishmen, or perhaps it would be fairer to say Anglo- or Scoto-Irishmen, have played a very prominent part in several fields of engineering effort. He claims for Ireland the credit of producing the largest telescope, the largest ships, the largest sluices, and the largest linen works and the largest rope works yet constructed. In some respects the most noteworthy of the above achievements was the great telescope at Parsonstown with its 6-ft. mirror. This was not merely designed, but was also constructed by Earl Rosse in his private workshops with the aid of a capable smith and such other assistants as he could readily obtain. The successful completion of this delicate piece of work under such conditions is a striking instance of what can be accomplished by a man of genius, when backed by willing, if untrained, labour. The president might, indeed, have substantially increased his list of the indebtedness by engineers to representatives of what it has been common, in some quarters, to call the "garrison" of Ireland. Through Sir Benjamin Baker this small community has a claim to share in the credit for the construction of the Forth Bridge. The names of Lord Kelvin and Osborne Reynolds again are familiar to all for their great and original contributions to the art and science of engineering; whilst to Sir Charles Parsons the world owes the steam turbine, which has halved the fuel consumption of electric generating plants and reduced the capital cost to an even greater degree.

The physicist is fortunate in that he has to wrestle only with matter, whilst the engineer, in his struggle with nature, is handicapped by the necessity of working by and with men. The difficulty of securing the harmonious co-operation of labour has been steadily increasing year by year. Directly and indirectly the struggle has checked the creation of wealth, and diminished the average standard of well-being of the community as a whole, and its poorer members in particular. As others have done before him, Sir Joseph Griffith looks forward to co-partnership as a possible panacea for the evil. Undoubtedly, as some of the labour leaders frankly admit, part of the labour unrest is due to ignorance, and the history of the South Metropolitan Gas Company during the past few years affords grounds for believing that the admission of workmen's representatives as active directors of an undertaking does tend to allay the suspicion that the labourer is being denied his fair share of the products of his industry. It is not a little noteworthy that the scheme so successfully worked out by Sir George Livesey had to be carried through in the teeth of the strenuous opposition of organised labour, and it will be remembered that the well-intentioned plan of co-partnership promoted by the late Lord Furness came to grief on the same rock. Moreover, in view of the frequency with which organised labour has of late years thrown over agreements negotiated by its duly elected representatives, it is at least an open question whether workman directors may not equally fail to retain the confidence of those they represent. Nevertheless, as ignorance is in the main at the bottom of most of the labour unrest of to-day, there is much to be said in favour of the proposal to introduce, where practicable, workman directors on to the Boards of industrial undertakings. This, however, can be possible only when an enterprise has attained a certain stage of development. Great creations of wealth are invariably due to the genius of some one individual. As the director of an ordinary limited liability company or as the manager of a co-operative society the late Mr. Carnegie would never have built up the steel industry of America. Indeed, as matters were, it is reported that he quarrelled with each of his partners in succession, and his ultimate success was attributable to the fact that he was able during the whole period of development to maintain a controlling interest in the undertaking, and thus could pursue his personal policy regardless of the doubts and fears of his less far-seeing associates. The result was to hasten the development of the Ame ican steel industry by perhaps fifty years. As one consequence life to-day is easier for every American citizen, whatever his position in society, than it would have been had Mr. Carnegie's pluck and enterprise been curbed by the necessity of satisfying some board of mediocrities as to the wisdom of every move he made. The universal introduction of working men directors would therefore, we fear, seriously check the creation of wealth in this country. In fact, it is very noteworthy how extraordinarily little has been effected in this way by the co-operative societies during the long term of their existence. They have invariably played for safety and left all pioneering work to others. It is in this pioneering work that great wealth is created or dissipated, and the nation that contents itself with the rôle of a mere copyist is little likely to enjoy any very high level of prosperity. Still, although for the reasons stated we do think that the appointment of workmen as directors might prove disastrous in many undertakings, there are undoubtedly others in which their presence on the Board might prove of great advantage, and in such cases we agree with the president that great good might be expected from the adoption of a policy permitting this.

THE INTERNATIONAL LABOUR CONFERENCE.

The first World's Labour Congress, now sitting at Washington, is charged with the duty of equalising so far as may be the conditions of labour in different countries. In those countries in which industrial evolution has progressed far there has been a not unnatural fear that the reasonable standard of

living so hardly achieved shall be jeopardised by cheap and overwrought labour in other countries. Probably the fear is somewhat exaggerated, since in spite of the relatively short hours worked here and the relatively good wages earned, we competed in the past not unsuccessfully with countries in which the conditions were much less favourable to the worker.

Three reports dealing with the matter have been prepared by the Organising Committee of the Congress. This committee is comprised of one representative from each of the following countries: The United States, Great Britain, France, Italy, Japan, Belgium and Switzerland, and has as its chairman M. A. Foulaine (France), whilst the secretary is Mr. H. B. Butler, the British representative. The first task of the committee was to obtain authentic first-hand information on labour conditions in the different countries comprised within the League of Nations. To this end they compiled a detailed *questionaire* to the governments concerned, and on the basis of the answers returned they have drafted recommendations which will be discussed at the Congress.

One of these has reference to the general adoption of a 48-hour week, but they admit that as yet the data available are inadequate for fixing in detail the exemptions or relaxations that may be necessary. With respect to continuous industries, such as iron-smelting, it is suggested that the hours of labour shall be such that the monthly average shall not exceed 56 hours per week, whilst a 60-hour week is proposed for caretakers, watchmen and the like, whose duties are of an intermittent or unexhausting character. Where work is liable to interruption by the weather, or where materials of a perishable character have to be handled, overtime may, it is proposed, be admitted to the extend of 150 hours per annum, the rate of pay being time and a quarter. In all other cases the overtime is to be confined to certain scheduled industries.

It should be observed that the above proposals are put forward merely as a basis for discussion, and the committee recognise that the conference may find it impracticable to confine overtime to scheduled trades; but should this be so, it is recommended that the amount should be limited to 150 hours per year at the outset, and that this figure should be reduced to 100 hours at the end of five years. In all cases where worked, the rate paid for overtime should not be less than time and a quarter. In countries where climatic conditions, or imperfect industrial development, make it impracticable to adopt the above scheme forthwith the committee suggest that the hours might in the first instance be reduced to 54 or 60 per week; or, alternatively, that these countries should agree to introduce the 48-hour standard within a limited term of years, applying it in the first instance to the labour of women and young persons.

Another important matter on which a draft proposal is presented is that of unemployment. It is stated that Labour Exchanges and the like have not proved as useful as was hoped; the Exchanges, in fact, are not generally able to supply information as to a workman's ability or as to the conditions of work, and they are therefore avoided not merely by employers but by the better class of workers as a body. An important proposal is that the different States should agree to assure reciprocal benefits to emigrant workers; whilst for the purpose of diminishing unemployment it is suggested that local and State authorities in all countries should, so far as is practicable, carry out public works during periods of slackness.

The third important proposal has to do with the employment of women and children. It is suggested that women should be prohibited from working in factories for a period of four weeks after childbirth, and that adequate maternity benefits should also be provided. Night work is to be prohibited not only for women, but for young persons of under 18, whilst children must not be employed under the age of 14.

What degree of unity may be achieved at the Conference, and to what extent the recommendations made can be carried out, it is yet too soon to say. But it is a happy augury that such a Congress should meet, representative of the great Powers of the world. The discussion of the conditions of labour in the various countries, differing, as they do, according to the past standards of life, must confer advantages, because they will at least educate public opinion in the respective countries represented. Hope therefore is justified, because the preliminary to all reform is the recognition of the true facts of the case. Moreover, it is desirable that the workers should realise the influence of international economics on the retention of old markets and the capture of new ones. This depends not so much on the rate of wage paid as upon the rate of output per unit of wage paid. Judged by this standard, high earnings are advantageous alike to the men who earn them and to the firms who sell the products of labour; and also to the nation, because where the manufactures are home-consumed the selling price is proportionately reduced, while the freer exportation of the manufactures to foreign countries tends in the best sense to add to the wealth of the nation.

NOTES.

Liquid Fuel Research.

We learn from a report of the General Committee of the Diesel Engine Users' Association, presented to the members and favourably received by them at a recent meeting, that that body proposes to form a research association for work in connection with the utilisation of home-produced liquid fuels in internal-combustion engines. The scheme includes the construction of a laboratory equipped with characteristic examples of Diesel and semi-Diesel engines, and also with tar-distilling plant, in which laboratory full-scale experiments could be carried out by a practical chemist, engineer and staff. As is now well known the Government, through the Department of Scientific and Industrial Research, is prepared, under certain conditions, to give financial assistance to such associations, one of the conditions being that the industry concerned should guarantee a certain definite sum annually for a period of five years. In this case the State would add pound for pound to the income of the association. It is thought desirable that the proposed association should, as far as possible, be controlled by engine users, and as such questions as the elimination of unsuitable fuels and the discovery of the best methods of utilising satisfactory fuels will form a very important part of the association's work, the scheme should certainly meet with hearty support from this class of interested party. To the engine builder the association may appeal less strongly, as the larger firms already possess considerable facilities for research work. The smaller firms, however, may be glad to avail themselves of the resources of the association, and, in any case, it must be remembered that the whole industry is likely to derive some benefit from the work. Much information is still needed on the subject of distilling fuel oils from tars, and also as to the employment of certain by-products of tar distillation, and, as the laboratory of the association would be equipped for investigations of this kind, it may reasonably expect support from tar producers and distillers. During the last few years our dependence upon supplies of imported petroleum for power production has been made painfully apparent to the whole community, so that any genuine efforts made towards the development and better utilisation of home supplies of liquid fuel should be regarded as of national importance. The present high price of coal also encourages attempts to discover substitutes, or, failing that, it shows the need for utilising coal and its by-products to the best possible advantage. The moment thus seems particularly opportune for the formation of an association with the objects indicated above.

Electrochemical Treatment of Seed Grains.

The paper on the Electrochemical Treatment of Seed Grains, which Section M. Agriculture, discussed at the Bournemouth British Association meeting was not the paper announced by Dr. Charles Mercier, who unfortunately died before the meeting, but a paper of the same title and dealing substantially with the same facts apparently, by Dr. A. E. Blackburn. The leading idea of the electrochemical treatment, as distinct from the treatment by atmospheric electricity, seems to be that electrolytes are introduced into the seeds to raise the osmotic pressure. In the process described by Dr. Blackburn, 10 or 20 sacks of grain are placed in a solution of some fertiliser salt, *e.g.*, sodium nitrate, contained in tanks which are provided with iron electrodes at both ends; the electrodes are joined to the electric mains. The treated seed is dried, which is a delicate operation; over-drying kills the seed, under-drying may lead to premature germination. The treatment is to precede sowing by a month or two. According to the Board of Agriculture the first experiments of this kind were made in Germany forty years ago. The Board republished those papers last February, and inquired carefully into the results of comparative experiments, made over here, which in the case of grain yielded an average increase of 10·5 bushels to the acre; the Board did not express any definite opinions as to the cause of the increase, however. Yet the interest in the treatment has spread, and some 500 farmers, in Scotland as well as in England, have tried it this year, realising in most cases a decided increase both in grain (wheat, barley, oats, also in potatoes sometimes) and in straw. Not all the speakers taking part in the discussion supported the treatment. Mr. A. E. Baines suggested that the seed and plant were in the soil in an electric field, the earth being mostly negative, the atmosphere positive. The skin of a dry horse-chestnut buried in the ground would correspond to the outer coating of a Leiden jar, the membranes to the glass insulation; if the electrodes were placed at the bottom and on the top of the soil, the current would, according to the polarity, favour growth either of the roots or of the stem; thus a great deal would depend upon the nature of the soil, as Mr. Ross Thompson pointed out. This, however, is not seed treatment. As to this Dr. Bletchley, of Rothamsted, stated that the laboratory experiments did not harmonise with the farm experiments, and the electrochemical treatment had done good and also harm. Mr. G. H. Garrad said that the treated crops first looked better, but the final results were doubtful, whilst Mr. H. H. Dunn, speaking as a seed merchant, stated that his inspection of many fields, on which he could compare treated and untreated seeds, had convinced him that the treatment improved both the growth and the yield in 90 cases out of 100. Dr. Anderson also spoke in favour of the treatment, though he could not trace the effect to any specific cause. We quite agree that that is no reason for discontinuing the experiments. But we are afraid that there still lingers in some people the odd conviction that electricity must do good. Dr. Blackburn mentioned that rubbing a stiff knee with salt water was no good, but electrical treatment would soon remove the stiffness. Possibly. But the advice of so simple and cheap a remedy as salt water does not impress the patient, and he does not bother to apply it; when he has to pay for expensive electric massage, he does not neglect the cure. All these electric seed treatments are somewhat of the nature of the whip. It might be understood that electrification of the soil, promoting the circulation in the soil and in the plant, might be beneficial, even if the currents are far stronger than the natural currents. It is less easy to see, however, why the treatment of the seed, weeks before the sowing, should increase the yield; it is like whipping a horse up for a race which is to be run some weeks later. Judicious drying may itself be useful.

Flight from Great Britain to Australia.—We are informed that Messrs. Vickers, Limited (Aviation Department) have entered a standard "Vickers Vimy-Rolls" bombing aeroplane to compete for the 10,000*l.* prize offered by the Government of Australia for a flight from Great Britain to Australia. The machine, of which some particulars will be found on page 604 of our last volume, will be piloted by Captain Ross Smith, M.C., D.F.C., A.F.C., and his brother, Lieutenant K. M. Smith, R.A.F., will act as reserve pilot and observer. Sergeants J. W. Bennett and W. H. Shiers will act as mechanics. It will be remembered that one of these machines was earmarked for a bombing raid on Berlin just before the signing of the armistice, and that another, with a few minor alterations, was used by Captain Sir John Alcock, K.B.E., D.S.C., in his epoch-making flight across the Atlantic.

THE MOTOR CAR SHOW AT OLYMPIA.

Six years to the day have passed since the last representative show of motor cars was held in England. In the interim the output of the factories has been changed in character, the designers having had their energies diverted to munitions and the guiding brains having been fully occupied with the special problems imposed by the war. The period since the armistice has, moreover, been full of difficulties; the works have required rearrangement to enable them to resume their normal trade, the staffs have only gradually been demobilised or diverted from their war-time occupations, and the manufacturers have been cut adrift from the usual lines that guide the progress of the industry, whether exhibitions, races or hill-climbing competitions. These causes, which have so deeply affected development in England and the Allied countries on this side of the Atlantic, have also retarded the evolution of the typically American car, although to a less extent, as the time lost in America has been shorter. The indirect influences of the war, therefore, have left their strongest impress on design, and of these the more important have been the introduction of mass production into the works, the possibilities ascertained by excessive weight-cutting in the design of aero engines and the experience obtained from the continuous use of existing designs under the abnormal conditions of roads and service near the front and at home. A new consideration has been introduced by the needs of the woman driver and the tendency to reduce all possible sources of heavy manual work to a minimum. This has shown itself in the use of self-starters to save cranking the engine, in transferring the brake and change levers to the inside of the car to reduce exposure, and in the adoption of wheels and tyres easier to interchange or remove. Absence of garage facilities and help has thrown more work on the owner-driver; those operations that have usually been performed when the car was laid up have, under the changed conditions, appeared in a more serious aspect, which is reflected in detail by changes of design for facilitating the operations of cleaning, oiling and filling. In view of the various points above referred to, it is evident that the show which opens to-day at Olympia is one which must be of very special interest to all car owners.

The Influence of Mass Production.

Before the war there were but very few firms in England manufacturing engines in what was then considered quantity. To-day the number has been practically doubled, and one firm—J. Tylor and Sons, Limited, of New Southgate—has constructed a model factory having a capacity of 100 engines per day. The pre-war engine builder generally made several patterns in the same works, but this highly-specialised firm is confining itself to the production of a single type—that suited to the largest market, namely, the small car for which the licence costs four guineas. The Tylor 3-in. by 5-in. engine has been designed for the Angus-Sanderson car, which is itself to be produced in very large numbers.

Following more nearly the pre-war practice, but with substantial output for each class, the firm of W. H. Dorman and Co., Limited, produce some 10 models, covering the range from light cars and generating sets to heavy motor lorry engines. During the war this firm was entrusted with the manufacture of the Constantinesco gear used for the control by fluid of machine-gun fire through the propellers of aeroplanes, a mechanism requiring workmanship of very great precision.

Post-war practice has developed specialisation not only in the prime mover as a whole, but also in its details, of which piston rings, crankshafts and valves were formerly the principal parts, made solely by individual firms. To-day the subdivision has been carried still further, and the list of parts, which now includes pistons, connecting-rods, helical gears and cylinders, has not finished growing. The white-metal liners for the big-ends of connecting-rods have come within the province of the die-caster and have added another class to the specialised products.

The light gear-box manufactured by Messrs. E. G. Wrigley and Co., Limited, the makers of "tank" gear-boxes during the war, has been produced as a self-contained unit carrying a central control lever and giving three forward speeds and a reverse. This firm also manufacture other components, among the more important of which are a standard steering gear complete with wheel, ignition and throttle levers; a back-axle for light cars complete with brake-drums and brake-gear; and also the propeller-shaft, with its casing and cardan joints for connecting this unit to the gear-box and axle. They have also produced a front axle of neat and original design. Evidence of the increasing accuracy of workmanship is afforded by the manufacturer's instructions that engine oil only, but not gear oil or grease, is to be used in these units.

The Manufacture of Details.

The principal details produced by highly specialised firms before the war were ball-bearings, carburettors, chains and chain-gears, sparking plugs and, to a very small extent, magnetos. The last-named prior to the war had been obtained almost exclusively from the greatest enemy countries, the steel being finished and magnetised in one and the machines completed in the other empire. The difficulties in which the aero-engine industry found itself early in the war, owing to the lack of manufacturers of magnetos and of the necessary technical knowledge to produce them, was a most serious handicap. It was necessary to make research on insulating materials, on the methods of moulding them and of obtaining the correct wearing qualities; further research was needed on permanent magnets, the steel of which they are made and its treatment; and experiments had to be carried out on existing magnetos to determine the limits for accuracy and workmanship and other factors. The result has been the building up of a group of magneto manufacturers, of which the more important are the Blic, North, Fellowes, M.L., Thomson-Bennett and others, in addition to the original Simms firm.

The other important "bottle-neck" in aero-engine building was in ball-bearings, the production of which was early in the war found to be quite inadequate. There were then but three firms manufacturing in quantity, and of these Hoffmann's, the largest, required to have their works doubled twice in the course of the war. During that period two new firms commenced the manufacture of these bearings, and the country has now become independent of foreign supplies. In France the Compagnie d'Applications Mécaniques (formerly the Roulements Billes Français, or R.B.F.) manufacture, in addition to the usual types, several special patterns of bearing of well-considered design, particularly the spherical-seated axial thrust bearings and spherical-housing bearings for radial thrust. This class of work is necessary where alignment is uncertain, and is provided for also in the models produced by the Skefko Company.

In carburettors, lubricators and minor details the changes have been small, but among novelties may be noted the Simms magnetic level gauge, a hermetically sealed arrangement, for use on pressure petrol tanks. A float provided with a guide-pin sliding in a spiral groove in a fixed tube and sliding also on a rectangular metal strip rotates this strip, which bears a permanent magnet at the upper end. Rise or fall of the liquid causes partial rotation of the magnet, the field of which passes through the cover of the tube and, acting on a steel strip carried by a light pivoted aluminium drum, causes the drum to rotate and to exhibit figures in the head of the gauge, giving the reading for the contents direct in gallons.

The pressed-steel road wheel has been gaining in favour and new models of dished wheels are now being produced. The Sankey pressed-steel wheel is used on a large number of cars, and a new type of waved disc is being produced by Messrs. W. Goodyear and Sons, Limited. An advantage of this design is that the valve fitting can be brought through the rim without cutting away any part of the disc.

Manufacture.

Not only has the quantity-production method been adopted for components and for small cars, but in one instance it is applied to a high-grade chassis with a six-cylinder engine rated at 29·5 h.p. and guaranteed to develop 60 brake horse-power. The Armstrong-Siddeley chassis is to be produced at the rate of 5,000 per annum, a figure which speaks for the confidence of the manufacturers in a large market for high-class cars of medium power. The catalogue price, moreover, is about one-half that of the smaller manufacturers. Taking account of this, and of the war-time production of the firm, it would appear as though the trade in the higher classes of cars would settle down into the hands of a very few firms, and that the firm producing only a few hundred cars per annum will before long be unable to maintain the struggle.

In the smaller cars the industry appears to be in a transition stage, passing from the building in the same works of each component of the whole car, only a few details being bought outside, to the American method in which firms specialise in components, one producing, for instance, nothing but worms and worm-gears, another specialising in steering gear, and so on. The car builder under these conditions becomes more correctly an assembler, but he must use his technical knowledge properly in order to take full advantage of the components obtainable on the market, and to build up from them the best combinations.

Methods of Manufacture.

The great developments in turret lathes have enabled output to be increased for many details that are capable of being made from bar or of being readily chucked; there remains, however, the great difficulty of resetting in much chuck work, and this can only be overcome by well-considered design in which the draughtsman must be as thoroughly in touch with the machine shop as the jig designer with the tool room.

Stamped and drawn steelwork parts already have a wide field, and their use is extending on the chassis. The drop-stamping is assuming forms with more rounded outlines and sections, shapes in fact that lead one to think that before long a modelling room may be added to the drawing office, and that as the sculptor makes his *maquette* or model of his figure with a framing of lead pipe to enable the arms or legs to be bent, so the engineer's modeller will work out the shapes of levers and casings for brakes, for steering gear and for other parts, in modelling clay on partly turned work to which pieces of lead are secured. Where metal patterns are to be made it is quite probable that the artist's methods would produce the single result desired much more rapidly than those of the pattern-maker and at considerably less cost.

Applications of pressed steel are growing also, but it is in the bodywork of the car that its real future lies. The chassis is cut down to a limit of weight by the exercise of great care in design and at increasing cost per pound saved in weight as the limit is approached. The same should apply to bodywork; it doubtless will do so when bodies are manufactured to a few standard designs only and by the car builders, instead of being made individually by coachbuilders to suit the personal views of the purchaser, a type of work to which the name "tailor-made" bodies is now applied. It is always instructive to examine a car body that has been partially destroyed by fire and to see how much and how heavy is the ironwork, forged and welded from bar, used in the ordinary construction. Some firms, such as Lanchester Motors, provide projecting plates to which the bodywork is to be fitted, but the coachbuilder does not take kindly to this assistance, and frequently the weight saved at great expense in the chassis is added recklessly to the body, which should rightly call for the same care and skill in weight-cutting. For this reason it is possible that pressed, instead of expensively beaten, aluminium plate may be used for much of the work, or the very light moulded fabric and veneer used for the cockpits of aeroplanes may form the major part of some of the more luxurious car bodies.

Modifications in Engine Design.

Taxation in the form of the licence based on a *bore* formula is responsible for driving the engine-builders to certain definite limits for cylinder diameter while leaving them free to vary the stroke. As a lengthened stroke within certain limits gives increased power, the tendency in the design of cars is to adopt a stroke/bore ratio of the order of 1·75

or thereabouts. In America those models which were standardised before the war, the Ford for example, have a stroke/bore ratio as low as 1·08. It is noteworthy that in the later, and also in the more luxurious American cars, the practice is approximating to our own, the average of 20 cars giving a stroke/bore ratio of 1·48. Twenty British cars of the same class give a stroke/bore ratio of 1·62 on the average.

The lengthened stroke and high compression have combined to increase pre-ignition due to fouling. Mainly for manufacturing reasons the Ford and the Silent-Knight engines adopted the detachable cylinder head, previously avoided for fear of trouble with the combined water and pressure joint. Once the jointing difficulty had been overcome other firms copied the arrangement, for it is far simpler to lift and replace the top than the whole cylinder-block, the putting in place of which means care and trouble over the insertion of each piston-ring. Cleaning, which has become even more frequently necessary with the use of inferior petrol, can be performed readily and more thoroughly by detaching the head than by any of the chemical methods.

Another modification in engine design that is regaining popularity is the overhead valve. It once had a considerable vogue, but was dropped on account of the increased number of parts and noise. In many cases also the overhead camshaft has been introduced. The first feature is taken from the aero engine, which is also responsible for the design of the zephyr or hour-glass type of piston, and for the use of aluminium for pistons as well as the narrowing of the piston rings. It is expected that the aluminium cylinder with a thin cast iron or steel liner will come into use, but—as the aero engine builders have learnt—this is a question of very skilled design supported by experience and experiment.

One car, the C.A.R., made by the Cosmos Engineering Company, Limited, has an interesting engine which is a direct descendant of the aero engine. It has three cylinders arranged on the fixed radial system and is air-cooled. An American air-cooled car, the Franklin, has been in use for a long time in the United States, but not many examples of air-cooled engines of more than 4 h.p. or 5 h.p., other than aero engines, are running in England.

The self-starter and the combined self-starter and lighting set are growing in popularity, and are now being fitted to most cars of over 20 h.p. In the case of some cars of low power, the Deemster light car built by the Ogston Motor Company (1918), Limited, for example, a hand starter is fitted to enable the engine to be restarted from the driver's seat, and an electric generating set is provided for the lighting.

Lubrication devices are being improved. In one car a pump is actuated by the movement of the steering wheel so that oil is forced occasionally—that is, when making a right-angle turn in one direction—to a number of the pin joints that only require occasional lubrication.

Accessibility has received greatly increased attention, perhaps as a result of war experience. It is now made possible to remove gears from gear-boxes and from back-axles more easily than hitherto. In fact, in one example it is stated that the bevels can be removed actually in mesh and examined out of the back axle for correctness of engagement. Such a method should ensure the elimination of one of the most troublesome sources of noise, a trouble dealt with in many chassis by the adoption of helical bevel gears.

Improvement is also to be noticed in the filling arrangements for fuel, oil and water on many cars, the fittings being now made more closely in keeping with the appliance that is to be used to introduce liquid, whether it be a can, a funnel or, in the case of water, a bucket.

Types of Cars.

Study of the price-lists of complete cars shows that at present the larger number of exhibits are cars ranging from 500*l.* to 600*l.* complete, and there are quite as many shown of higher values rising up to 2,000*l.* as there are of lower price ranging down to 200*l.* in round figures. Allowing for abnormal manufacturing conditions there are several exhibits which, under a return to pre-war cost of living, might be expected to fall within the 100*l.* figure. The large number of cheap American cars sold before the war is a sufficient indication that there is a market for the cheap car. It is only by progress in the specialisation of detail and component manufacture, by standardisation of chassis and car body that we can hope to see the evolution of a really cheap, efficient, light and serviceable British car and its production in sufficient quantity to meet this demand.

In our issue of last week we illustrated and described the Ruston-Hornsby 15·9 H.P. car and the Crossley 25–30 car now at Olympia, and several other exhibits are similarly dealt with this week. A detailed report of the Show will be commenced in our next issue.

LITERATURE.

The Chemistry and Manufacture of Hydrogen. By P. Litherland Teed, A.R.S.M., A.I.M.M., Major R.A.F. London: Edward Arnold, 1919. [Price 10*s.* 6*d.* bound.]

The growing importance of the hydrogen industry certainly justifies the publication of an English book on the manufacture of hydrogen. "Though our national requirements are perhaps the greatest, it is noteworthy that our contribution to the technology of hydrogen is probably the least of any of the Great Powers" Major Teed says in his preface. He also expresses his thanks to the Director of Airship Production for permission to publish this book. The reader hence expects and finds special reference to hydrogen generation for aircraft and near the front in warfare under conditions when economic considerations counted for little. These special references are also met with in the first two chapters of the volume on hydrogen and its occurrence and on its chemical properties. The two chapters take up 38 out of the 152 pages of the octavo volumes and are supplemented by an appendix of six pages on the physical constants of hydrogen. The chemistry of hydrogen is so vast that the information given must necessarily be somewhat scrappy, and we may regard these chapters as introductory to the main subject, the manufacture of hydrogen. This is dealt with in the three further chapters classified under the headings of chemical, physico-chemical and physical methods. As the only methods mentioned under the last heading are electrolytic, Major Teed might as well have adopted the latter term; it does not much matter, but there is no allusion to any other possible physical methods, and we do not quite appreciate why electrolysis is physical and not chemico-physical.

The choice of a hydrogen process depends upon many conditions among which output and transport facilities stand foremost. For commercial outputs of about 1,000 cub. ft. per hour Mr. Teed would in general recommend electrolysis, especially when the oxygen can also be utilised; for larger outputs the iron contact process, the Linde-Frank-Caro process or the catalytic process of the Badische Anilin Fabrik; but large requirements may make the silicol hydrogenite and hydrolith processes, &c. preferable. The purity of the hydrogen will demand very careful attention. When the gas is evolved from iron, or also from zinc by acids, traces of sulphur, arsenic, and phosphorus may be intolerable; the PH_3, *e.g.*, attacks copper and brass fastenings of aircraft and indirectly the textile fabrics. The action of caustic alkali on zinc yields a purer hydrogen; to this class belongs also the Majert-Richter process for balloon inflation, heating of powdered zinc and slaked lime in retorts. In the "silicol" process, which is described in detail,* silicon or ferro-silicon is decomposed by caustic soda. As the process yields more hydrogen than the usual proportions of 1 part of silicon to 1·7 parts of caustic should produce, according to the formula

$$Si + 2\,Na\,OH + H_2O = Na_2Si_2O_3 + 2\,H_2,$$

Mr. Teed thought that the silicon might directly react with the water; but he could not evolve hydrogen from silicon and water, even when superheated, and he suggests that the silicate formed further reacts with the water. The silicol process gives a fairly pure hydrogen, but it is expensive and—as pointed out—not quite so safe as it looks; explosions have occurred. The reaction generates considerable heat, and may become violent unless the powdered silicon is fed very gradually into the caustic of 25 per cent. at 180 deg. F. Alkali may be splashed about and be concentrated, when deposited in dry spots, and then become too energetic. Red lead must not be used in the joints of the apparatus, since the reduction of the lead oxide by silicon might give rise to dangerous heating, and air must, of course, carefully be excluded from the apparatus. In the Jaubert "hydrogenite" process of the French Army—the first silicol patent was taken by the Consortium für Elektrochemische Industrie—the caustic soda is partly replaced by slaked lime.

The generation of hydrogen by the direct decomposition of water by metals of the alkalis and alkaline earths, has no technical importance. The Bergius process-action of liquid water at high pressures and temperatures on iron—which we noticed some years ago—may prove of the highest value, Mr. Teed considers, if the mechanical difficulties can be overcome, as to which there has been no recent information. The decomposition of water by the alkali hydrides seems to be entirely out of the question, but Mr. Teed speaks of the possibility of using lithium hydride Li_2H_2 for replenishing the hydrogen of our ships, because the hydride has a very small weight (lithium, density 0·58, is the lightest solid element known) and yields most hydrogen. It would be more satisfactory, if he had told us where to find further information concerning this hydride, and as to its preparation and properties. The literature on the hydrides is scanty and rather discordant, also as to the formulae. Calcium hyride is the material used in the "hydrolith" process, also due to Jaubert, of the French Army. The "sical" process of Fuerstenburg and Philipps makes use of a powdered mixture of aluminium silicide and sodium, which is placed in water; Mr. Teed is not aware of actual application of the process.

Passing to the processes based upon the decomposition of steam—not liquid water, as in the processes so far noticed—Mr. Teed first describes at some length the manufacture of water gas, distinguishing the English method and the Swedish method of Dellwik-Fleischer (the name is misspelt Dellwick in the book). These distinctive terms are unusual, and the water-gas manufacture is a subject by itself, welcome in the book, but not much more entitled to special discussion in it than the compression of hydrogen, about which nothing is said at all. Yet the generation of hydrogen from iron and steam by the iron contact process, begins with the action of water-gas on iron oxide, and much of the commercial hydrogen is still made by that process, though Mr. Teed does not believe that it will long continue to enjoy its prominent position. His illustration of the Dellwik-Fleischer form of blue water-gas furnace is taken from the original patent specification of 1896, duly supplemented, and the iron contact plants described are the multiple-retort and single-retort (Messerschmitt) types. Mr. Teed would, on the whole, prefer the single retort as the more simple to construct and to work, though there would be little to choose between the two types as regards chemical efficiency. The other water-gas processes noticed are the catalytic process of the Badische Anilin-und Sodafabrik, and the water-gas and lime process of the Griesheim-Elektron-Gesellschaft (not Greisheim). The former firm passes blue gas and steam at 400 deg. C. or 500 deg. C. over a catalyst which is prepared by precipitating ferric nitrate, mixed with nitrate of nickel and of chromium, by potassium carbonate. The worst poison for this catalyst is chlorine. Among the miscellaneous methods mentioned are the acetylene-decomposition process of the Carbonium Gesellschaft, used at Friedrichshafen (misspelt Frederickshaven in the book) on the Bodensee for airship inflation; the oil-cracking process of Rincker-Wolter; and the fermentation of starch by the Fernbach bacillus, which yields acetone and butylalcohol, and hydrogen as a by-product (Bedford process).

The fourth chapter on chemico-physical methods

* We illustrated a silicol plant on page 103 of our issue of January 17 last.

deals briefly with the Linde-Frank-Caro process, liquefaction of blue water-gas for the generation of hydrogen, but gives references to the literature on the subject which we miss in most other instances, in which references are limited to patents. The diffusion method of Youve and Gautier again starts from blue water-gas. Mr. Teed is not aware that this process has passed into the commercial stage, and he has good reasons for doubting that the gas separation by centrifugal forces will prove technically successful. We have already mentioned the electrolytic processes of the fifth and last chapter which might contain some references.

While instructive, particularly as to novelties of warfare practice, the book bears evidence of hurried compilation. We do not wish to apply any essay standard to the style of a technical publication. But more regard might sometimes have been paid to the mode of expression. In the description of the silicol process three consecutive paragraphs begin: "The grade [subdivision, strength] is very important." In explaining the decomposition of water by metals the phrase "if lithium [potassium, etc.] is placed in water, it is attacked . . ." is repeated five times. This is not for brevity sake, for those two pages of brief notes and similar formulae might have been condensed into half a page. Similar repetitions occur in many other instances throughout the book. "Ammonia" we read on page 29 "is an easily liquefiable gas, and consequently it is owing to this property that it is employed . . ."; and on page 122 we find, "If the porosity of a material is too great, no diffusion takes place, but the gas passes through the material without appreciable separation taking place." There are other shortcomings. "Schoop states that when either gas [hydrogen or oxygen] contains 6 per cent. or 8 per cent. of the other, it is explosive," as if Schoop alone had studied these reactions; and the remarks on the hydrogenation of fats mention only one name, and that repeatedly, Sabatier, not even that of his collaborator, Senderens. We should not have referred to these points, if the book did not appear to have been written particularly for Major Teed's colleagues.

Naval Architects' Data. By J. MITCHELL, A.M.I.N.A. Edited by EDWARD L. ATTWOOD, O.B.E., M.I.N.A. London: Longmans, Green and Co., 39, Paternoster-row. [Price 7s. 6d. net.]

THE success with which the many and varied requirements of shipowners are met and the exacting conditions laid down by Naval authorities fulfilled would seem to indicate that the design of a vessel to meet any given set of conditions involved merely the correct application of a series of definite mathematical formulæ to ensure success. That this view is far from correct is well known to all designers of ships, for with the exception of such calculations as are concerned with the purely geometrical features of the ship there are very few which give a quantitative result directly applicable to the design in hand. The reasons for this are chiefly due to the indeterminate character of the conditions under which the vessel performs while at sea and to the inequalities of workmanship and material in the ship's structure. In practice the designer endeavours to standardise the assumptions which must be made for the purpose of his calculations and evaluates the result by comparison with the calculation for a previously built ship which has given good results in service. In this way the collection of data relative to a large number of completed vessels forms one of the most important duties of the naval architect, and indeed in the more important shipyard drawing offices a separate department for the collection and classification of these data is maintained. In regard to the tabulation of data most of the large firms have evolved a standard form for their own use, but a systematic method of recording data is by no means as universally adopted as it should be. It is therefore a pleasure to find a naval architect of the standing of Mr. E. L. Attwood collaborating with Mr. Mitchell in the production of a volume designed for the systematic recording of ships data.

The authors have made provision for the recording of most of the information usually found on the midship section together with data relative to weights of hull and outfit, tonnage, freeboard, bunker, hold, and water ballast capacities, main and auxiliary machinery, complement, &c., while space is also provided for recording at various drafts the information generally found on the displacement sheet. In view of the fact that the work of the ship designer is generally carried out in the drawing or designing office and that it is the standard practice to keep such plans as midship section, lines, general arrangement, and displacement scale always available it seems doubtful if it is worth while recording much of the information for which the authors have made provision. The fact that the spaces available for the insertion of figures are in many cases extremely small, directs attention to the crowded nature of the pages and suggests that a re-arrangement would be beneficial. Many items appear to be of doubtful value for record purposes, *e.g.*, height of rails, stern overhang, transom width, knuckle depth, &c., and such information is much more conveniently got from the lines or offset sheets. The estimating summary requires extension, notably in respect of positions of c.g. of hull in various conditions, indeed, an extremely useful addition would be columns for recording the positions of c.g. of hull, machinery, cargo space, and water ballast tanks. Capacities of holds and hatches are usually and most conveniently expressed in cubic feet or in tons of 100 cubic feet per ton. For estimating purposes the tables of formulæ and approximations which precede the pages for recording data contain the coefficients in the form in which the naval architect uses them, and the working up of these coefficients for each vessel dealt with should form the logical sequel to the recording of the data in the spaces provided. Space for recording these coefficients is provided for only three vessels, whereas the coefficients should be recorded for each vessel along with the data relative to the vessel, as only in this way can the full value of coefficients for estimating purposes be obtained and the most suitable coefficients be selected. Perhaps in a future edition this point may be allowed for and the value of the volume as a complete record of data will certainly be much enhanced if this be done. Tables of logarithms, anti logarithms, squares, cubes, areas of circles, &c., are provided at the end of the book, and will obviate reference to any other volume for information of this nature.

BOOKS RECEIVED.

The Aircraft Identification Book: A Concise Guide to the Recognition of Different Types and Makes of all Kinds of Aeroplanes and Airships. By R. BORLASE MATTHEWS and G. T. CLARKSON. London: Crosby Lockwood and Son. [Price 3s. 6d. net.]

Technic of Surveying Instruments and Methods. By WALTER LORING WEBB, C.E., and JOHN CHARLES LOUNSBURY FISH, C.E. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 9s. 6d. net.]

The Analysis of Minerals and Ores of the Rarer Elements. By W. R. SCHOELLER, Ph.D., and A. R. POWELL. London: Charles Griffin and Co., Limited. [Price 16s. net.]

Regulations for the Electrical Equipment of Ships. Issued by the Institution of Electrical Engineers. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 2s. 6d. net, in paper or American cloth covers, 3s. 6d. net in cloth covers.]

Guide to the Study of the Ionic Valve. By WILLIAM D. OWEN. London: Sir Isaac Pitman and Sons, Limited. [Price 2s. 6d. net.]

Fuel Economy. By W. H. BOOTH, F.G.S. Second Edition, revised. London: L. Rentell and Co., Limited. [Price 2s. 6d. net.]

Circular of the Bureau of Standards, No. 75. *Aluminium and its Light Alloys.* Washington: Government Printing Office. [Price 20 cents.]

Electric Mining Machinery. By SYDNEY F. WALKER. London: Sir Isaac Pitman and Sons, Limited. [Price 12s. 6d. net.]

END OF THE BENZOLE TRIALS.—The 5,000 miles test of a Triumph motor cycle, and the 10,000 miles test of a Sunbeam car, using benzole as fuel, were concluded on Wednesday afternoon last, November 5, when the vehicles arrived at the headquarters of the Automobile Association, Fanum House, Whitcomb-street, London. The Sunbeam car commenced its test on August 28, while the Triumph motor cycle started on September 11, since which dates they have traversed practically all the main roads in the country from Land's End to Inverness. The tests were instituted with the object of reassuring motorists as to the suitability of National N.B.A. benzole as a suitable, efficient, and safe fuel for motor vehicles. The tested engines are to be taken down and carefully examined, and in due course a full report on their condition will be issued.

CATALOGUES.

Tank and Draught Gauges.—These gauges were fully illustrated and described in our columns (vol. civ, page 120). One type is for fixed tanks and the other for measuring the contents of tanks or the draught of ships at sea. The makers, Messrs. Kelvin, Bottomley and Baird, Limited, 18, Cambridge-street, Glasgow, send two catalogues, one for land and the other for marine types. In all cases these gauges are specially made to suit the required purpose.

Bright Steel.—A considerable range of accurately finished steel, in round, hexagon, square and flat section, made by the Jones and Laughlin Steel Company, Pittsburgh, U.S.A., is now stocked by Messrs. Hall and Pickles, Limited, 64 Port-street, Manchester. The statement in the catalogue "by using any other make of bright steel a great deal of time is wasted in keeping the cutting edge on the tools, and taps and dies are easily broken" is not warranted. It is common practice in this country to screw thousands of pieces from British-made bright steel without either re-sharpening the tools or breaking them.

Deep Sea Thermometers.—Messrs. Negretti and Zambra, 38, Holborn Viaduct, E.C. 1, send a catalogue of their special instrument for taking sea temperatures at any desired depth with several types of frame for reversing the thermometer. The instrument will stand a pressure up to 3 tons per square inch, and is supplied with scales for general, arctic or tropical use. The introduction describes the various improvements in the instrument from 1857, when the first was made in response to a request by Admiral Fitzroy (presumably the Fitz Roy of Darwin's famous book).

Electric Traction Equipment.—A very comprehensive catalogue of components and parts for automatic signalling; trolley, car and line fittings, current collectors, heads and shoes; trolley heads, wires, conductors, standards and operating contacts; transmission lines and fittings; and, practically, all tramway and similar equipment comes from Messrs. Brecknell, Munro and Rogers, Limited, Thrissel-street, Bristol. The catalogue preface states that the aim of the firm is to offer a full supply in all these departments so that home buyers may be independent of imports from enemy countries. Each part is fully illustrated, described and coded for ordering by telegram. The catalogue should be in the hands of all tramway and light railway managers and engineers.

Valves and Vats.—Some 20 illustrations of very large valves and vats, with brief descriptive matter, form the subject of a special catalogue issued by Messrs. J. Blakeborough and Sons, Limited, Brighouse. The first is a sluice valve of 94 in. diameter, weighing over 25 tons complete; another of 2 m. diameter, weighing over 40 tons complete with hydraulic cylinder for operating, six of these were made for the French Admiralty; and quite a number of 48-in. valves are shown. Sluice gates penstocks, a 42-in. stop valve (for automatically shutting off water supply in case of a burst) and a turn-over filter are illustrated. A fine example of casting is a mixing vat—a pot-shaped vessel, cast with four feet 125 in. diameter and over 9 tons weight. These are most creditable specimens of a class of work requiring special experience and appliances.

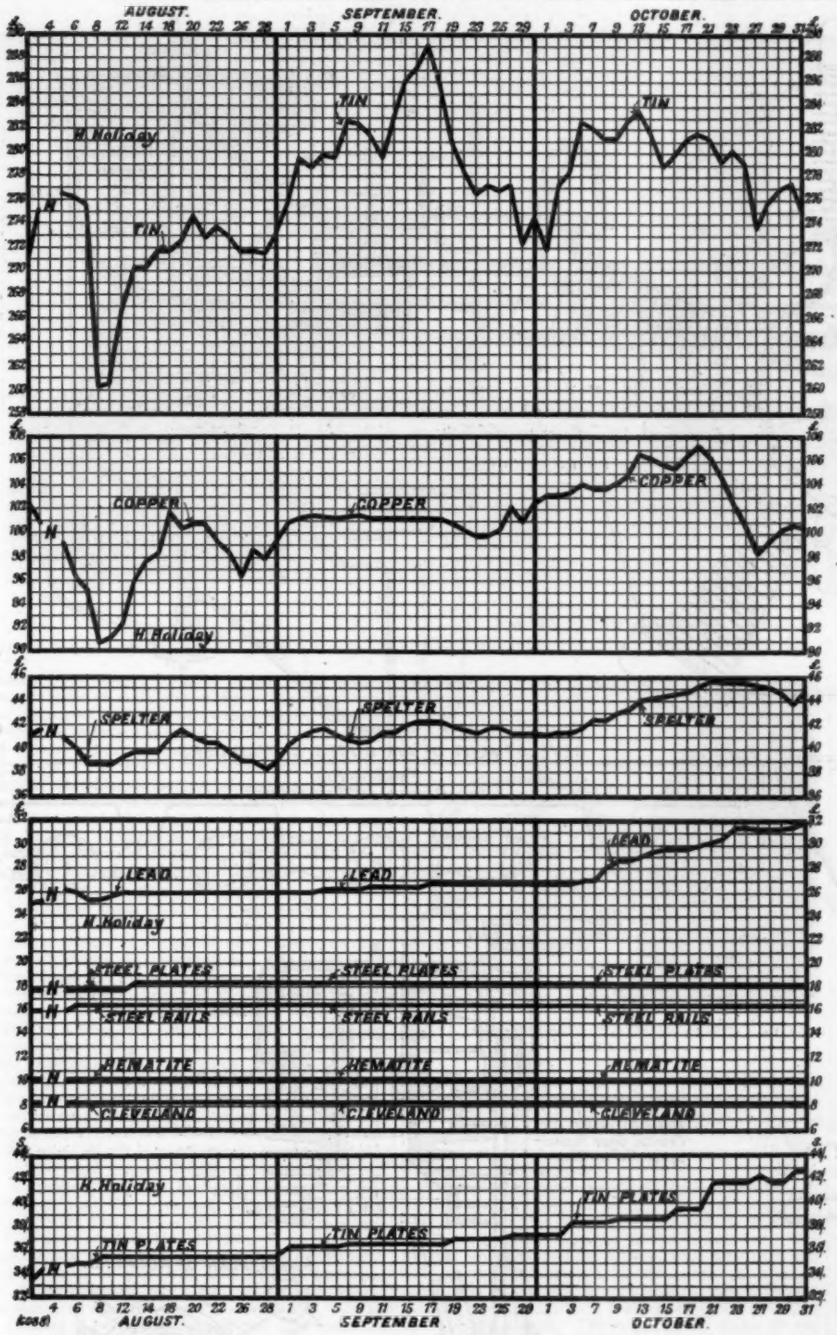
Pumps.—The catalogue of pumps issued by A. G. Mumford, Limited, Colchester, represents the best of engineering work in this branch—one of the earliest and still one of the most important. These pumps are for general water lift, boiler feed, ballast, liquid fuel, air, &c., and are generally with steam engine or electric motor drive incorporated in the machine; but also adapted for belt drive. Horizontal and vertical ram pumps, single and double-acting and also centrifugal pumps are shown. The firm's special valve gears, automatic control tank and gear, and automatic float tank are fitted when required. An excellent unit made for the Admiralty includes a surface condenser and combined air and circulating pumps, the condenser being supported on four polished columns above and clear of the machinery. Another fine unit for Colonial land use is a vertical boiler complete with its own feed pump and duplex pump on one baseplate.

INSTITUTE OF TRANSPORT.—Last Monday, Sir Albert Stanley gave a luncheon at the Savoy Hotel to experts in all branches of transport, when the announcement was made of the decision to form an Institute of Transport, for the scientific study of all questions connected with transport and traffic. Sir Eric Geddes has been invited to become the first president of the Institute.

THE LATE MR. EDMUND LEGH HARRIS.—We regret to have to announce the death on the 2nd inst., at Maitland Park, Haverstock Hill, of Mr. Edmund Legh Harris, a civil engineer who carried out a large amount of work in Russia. After completing the engineering course of study at King's College, London, Mr. Harris served under Mr. P. Pritchard Baly as assistant engineer. From January, 1865, to August, 1870, he was employed on the construction of the Poti-Tiflis Railway and the Keraiaz Irrigation Canal in Transcaucasia. He entered the service of the Russian Steam Navigation and Odessa Railway Company in February, 1871, and remained until 1878, during which period he executed numerous engineering works in his own projects and under his own responsibility in South Russia, in Odessa Harbour, and the surrounding district. Later on he had charge of extensive railway works in the same Russian territories. Mr. Harris was, since February, 1882, a member of the Institution of Civil Engineers.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

TRADE OF BRAZIL.—A limited number of the publications of the British Chamber of Commerce of Sao Paulo and Southern Brazil are available at the Department of Overseas Trade for the use of British firms. These include the Chamber's Annual Report and the "Report on the Trade and Industry of Brazil in 1918." British firms are to apply to the Latin America Section, Department of Overseas Trade, 4, Queen Anne's Gate Buildings, S.W. 1, may either consult or receive these reports.

SHIPPING BETWEEN CANADA AND SINGAPORE.—We read in *The London and China Telegraph* that a new sea route has been established between Canada and Singapore. The Canadian Pacific Ocean Services, Limited, have inaugurated a direct freight line from Vancouver (British Columbia) to Malaya. In this service they are making use of the steamship Methven. This service, if successful, will lead to the employment of other vessels.

EXPLOSION OF A CAST-IRON TANK AT HULL.

A REPORT has just been issued by the Board of Trade under the Boiler Explosions Acts, 1882 and 1890, of a preliminary inquiry that has been conducted by Messrs. James P. Turnbull and Charles Harvey, assistant surveyors, with regard to the explosion of a steam-heated cast-iron tank which occurred on March 2 last at the chocolate factory of Messrs. Needlers, Limited, manufacturing confectioners, Sculcoates-lane, Hull.

The tank was of rectangular form, its external dimensions being 4 ft. 3 in. in length, 3 ft. 6 in. in breadth, and 9½ in. in depth. The enclosed steam space was 4 ft. 1 in. in length, 3 ft. 4 in. in breadth, and 2 in. in depth. The report gives full particulars of the thickness of the plates and the construction of the tank, &c., and states that the tank was one of a set of four which were installed at the factory during August and September, 1916. The tank which failed was not insured, and had not been inspected internally since it was installed, but it was always under general external examination by the works engineer, Mr. James Wakes. It was also examined externally and hammer tested by an employee of the makers shortly after it was installed, and after one of the other tanks had failed.

The report states that the explosion was of a violent nature, the whole of the bottom of the tank being forced out and fractured into a number of pieces, leaving an aperture equal to the area of the bottom of the tank, through which the contents escaped. A girl was injured but fortunately only slightly.

The explosion, the Board of Trade surveyors' report states, appears to have been caused by the bottom of the tank becoming weakened, due to the development of a number of cracks on the inner surface, and also to two of the cast-iron stays between the top and bottom of the steam space having previously broken, as indicated by the appearance of the fracture. Most of the broken pieces of the bottom show, by the appearance of the fractures, that the cracks had extended for fully half the thickness of the metal. These defects, coupled with the broken stays rendered the tank incapable of withstanding the pressure of steam.

The report, in some general remarks, goes on to explain, that the tank was used in the process of chocolate refining, and was supplied with steam from a Lancashire boiler having a working pressure of 150 lb. per square inch, but it was usually worked at 100 lb. to 110 lb. per square inch. A reducing valve set to work at 25 lb. per square inch was interposed in the pipe line supplying steam to the machinery in the chocolate factory. Full details of the arrangements are given in the report, which further states that Mr. Percy Lazenby, works manager to Messrs. Needlers, had informed the Board of Trade surveyors that when the tanks were first installed, the late engineer, Mr. Hunter, in trying them, admitted steam at full pressure direct from the boiler, with the result that the bottom of one of the tanks was fractured, but not blown out. Mr. Lazenby stated he had never observed a higher pressure than 20 lb. on the "conche" gauge in connection with the tanks, and that the usual pressure at the time was 10 lb. to 20 lb. Messrs. Baker, the makers of the tanks, had advised the purchasers that the tanks had been tested at their works to a pressure of 60 lb. per square inch, and that they would be quite safe for a working pressure of 20 lb. per square inch.

After reference to the various facts connected with the working of the tanks, pressure, attendance, &c., the surveyors conclude their report by stating as follows:—

"We do not think that the pressure within the tank was greater than it should have safely borne had it not been weakened by the development of the defects previously described. The precautions which are now being taken should guard against any further risk of accident."

In the "Observations" made by the Engineer-in-Chief to the Board of Trade, Mr. Carlton concludes the report as follows:—

"This explosion illustrates the danger of subjecting cast-iron vessels to pressures for which they are utterly unsuited, and it is probable that the tank was damaged by the ill-considered action of the former works engineer who admitted steam to it at the boiler pressure. Damage sustained in this way is not always apparent at the time and may, as in this case, remain unsuspected for considerable periods while accentuating any latent defects which may, and do frequently, exist in castings, of a complicated form. The cast-iron studs or stays, such as were fitted in this case, are particularly liable to fracture, and form an uncertain method of supporting the flat surfaces. Moreover, the arrangement of the exhaust pipe was such as permitted the bottom of the vessel to remain covered with water, and consequently the temperature stresses would be very high whenever steam was admitted.

"It is satisfactory that steps have been taken to ensure safer working conditions in the future, but care should be taken that the safety fittings are continuously efficient, and the apparatus should be inspected inside periodically as far as is possible, and a suitable hydraulic test pressure should be carefully applied."

SIR RICHARD REDMAYNE AND THE COAL MINES.—Sir Richard Redmayne, K.C.B., has relinquished the temporary position which he accepted in 1917 as Director of Production and Technical Adviser to the Controller of Coal Mines, and has resumed his permanent duties as Chief Inspector of Mines at the Home Office. Sir Richard Redmayne has, however, consented, with the approval of the Home Secretary, to place his services, in an advisory capacity, at the disposal of the Controller of Coal Mines with regard to pending legislation affecting the coal-mining industry.

ENFIELD-ALLDAY 10-H.P. MOTOR CAR WITH AIR-COOLED ENGINE.

CONSTRUCTED BY MESSRS. ENFIELD-ALLDAY MOTOR COMPANY, LIMITED, BIRMINGHAM.

Fig. 7.

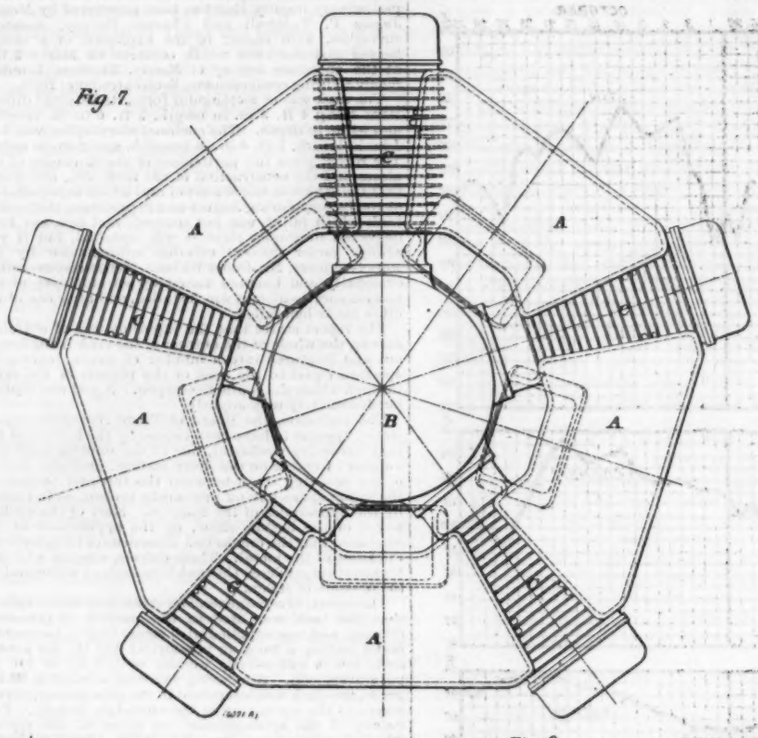


Fig. 8.

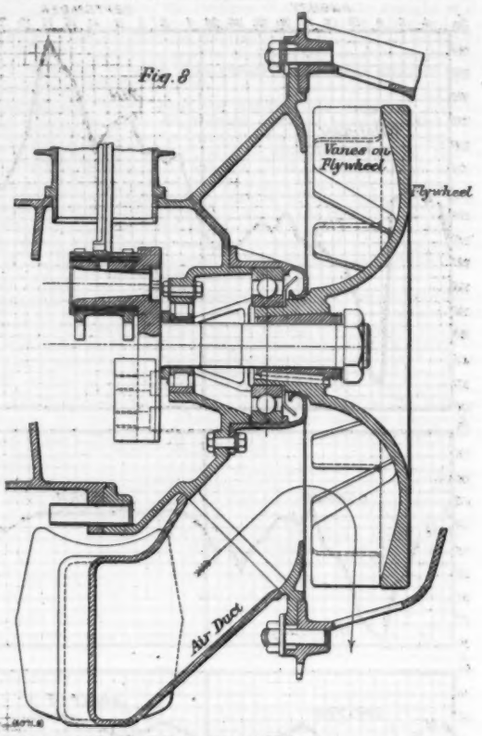


Fig. 10.

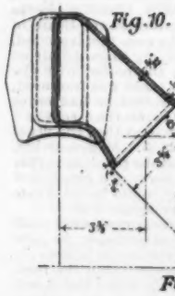


Fig. 12.

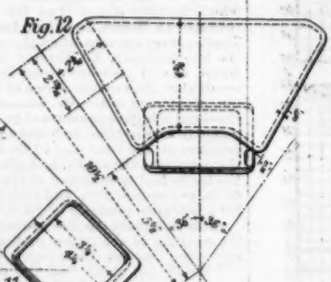


Fig. 11.

Fig. 9. DEVELOPMENT OF AIR DUCTS & CYLINDERS.

Fig. 13.

Fig. 14.

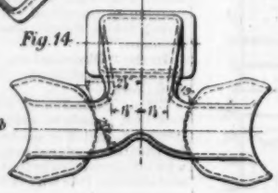


Fig. 15.

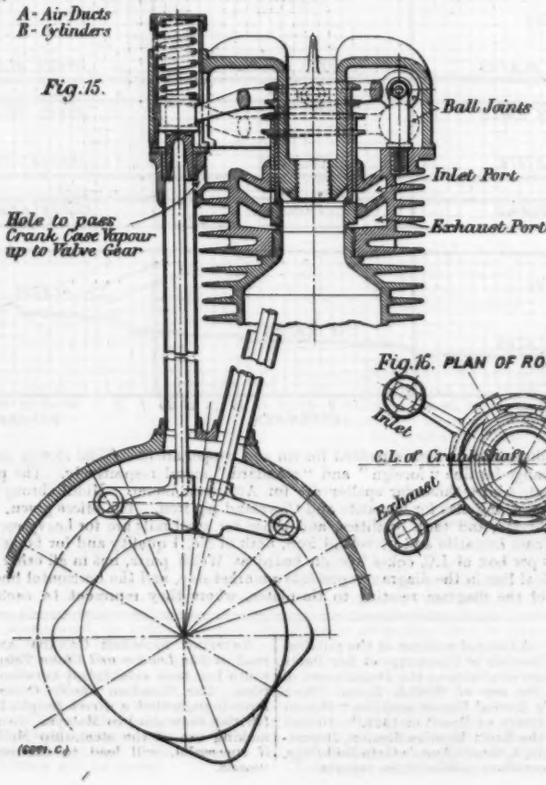
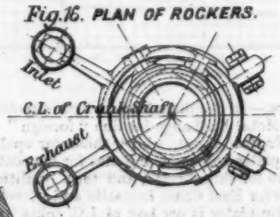


Fig. 16. PLAN OF ROCKERS.



It may be anticipated that light cars will form an important feature in the motor exhibition at Olympia, which opens to-day. No inconsiderable part of the extra machinery manufacturing capacity which the war has brought into being has been diverted, or is in process of being diverted, to the manufacture of the lighter class of motor car, and this will result in the appearance of many entirely new cars and exhibitors at Olympia. In addition, however, it will probably be found that many of the older makers are giving very considerable attention to the light car, and they may be expected to bring forward many new models. It is not necessary to make comparisons, but it is doubtful if, when the show opens, it will contain any model of greater interest, from the point of view of the possibilities of new design, than the Enfield-Allday 10-h.p. light car, which we describe in this article. This car, which is manufactured under Reeves patents by Messrs. Enfield-Allday Motors, Limited, of Fallows-road, Sparkbrook, Birmingham, illustrates to what extent it is still possible for original design to get away from what have become more or less standard lines in motor-car lay-out and detail.

The principal features in which the Enfield-Allday

ENFIELD-ALLDAY 10-H.P. MOTOR CAR WITH AIR-COOLED ENGINE.

CONSTRUCTED BY MESSRS. ENFIELD-ALLDAY MOTOR COMPANY, LIMITED, BIRMINGHAM.

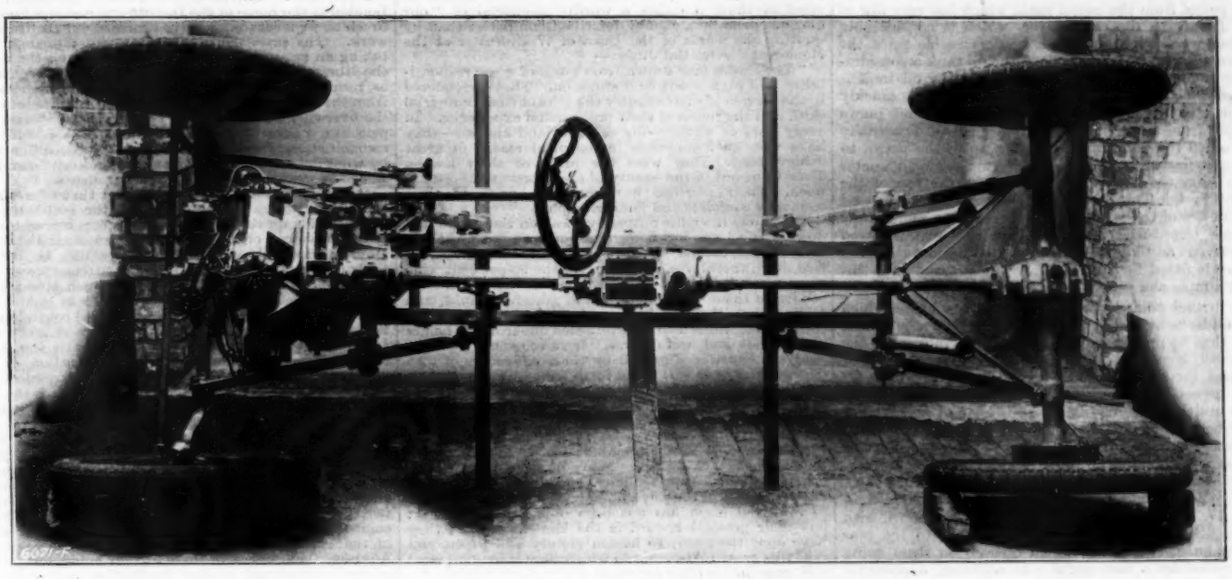


FIG. 17. PLAN OF CHASSIS.

car differs from others of a more conventional design are in the form of main chassis frame employed and in the fitting of a radial air-cooled engine. Before proceeding to details it may be well to say something of the objects which the designer of this novel car has had in view. The first consideration has been the attainment of lightness, or more accurately the reduction of dead load. So successfully has this idea been carried out that the tare weight of the four-seater car is only 10 cwt. It would be easy to find examples of four-seater light cars of double this weight. The most important result of the reduction of dead load is, of course, the effect on petrol consumption, and it has been found that under general average conditions the car can without difficulty cover 45 miles to the gallon. The special design of engine is also stated to very considerably reduce oil consumption. A further result following from the weight reduction is that more life is obtained from the tyres. It should be noted that this reduction of dead load has not been obtained by indulging in a very light construction throughout, but by entirely modifying the main features of standard design. The adoption of the radial air-cooled engine has given a power unit which weighs less than 1 cwt. and can develop over 30 h.p. at 2,500 r.p.m. A further point which may be mentioned is that, as the engine is of very small length in a fore and aft direction, considerably more length is available for the body of the car for the same overall length as would be given were a standard type of four-cylinder engine used. At the same time the extra body length obtained lies wholly between the axles, a position which, as is well known, is most comfortable for riding.

Turning now to the details of the car we may refer to Figs. 1 to 4, on page 618, and Fig. 17, annexed, which, taken together, give a good idea of the general arrangement of the chassis. The frame, as will be seen, consists of two triangular stamped steel members connected together by various tubular cross-members. Both front and rear suspension are on cantilever springs which are splayed out from their points of connection on the frame. This is well shown in Fig. 17. The frame is essentially of very simple construction and contains few parts. It is claimed by the makers to have remarkable rigidity for its weight, as compared with other forms. It will be clear from the illustrations that the frame works in remarkably well from the point of view of the various attachments which have to be made to it, and that there are no odd brackets and other parts bolted on to carry the various connections. For the splayed spring suspension it is claimed that the oscillation of the body consequent on one, or more, of the wheels running over an obstacle, is much less than in the more usual construction. The method of mounting the engine on the frame is shown in Figs. 3, 5 and 6, on page 618. As will be seen, the tubular

FIG. 18. STEERING WHEEL SHOWING TILTING ARRANGEMENT.

cross-member at the front of the frame carries two upright tubular supports terminating in sockets which are bolted to the engine casing. Further support to the engine is given by the hollow distance-piece which connects it to the gear-box and inside which the connecting shaft is carried.

The engine is of the fixed-cylinder radial type. It has five cylinders and, as has already been mentioned, is air cooled. The cylinders are 68 mm. in diameter, and have a cubic capacity of 1,450 cub. cm. The pistons are of aluminium bronze, with four thin and deep rings. The connecting rods work on a single crank, one of the rods being provided with a big-end carrying outside lugs with bearings to which the other rods are connected. The sequence of firing of the cylinders is 1, 3, 5, 2, 4; that is, there is an impulse every two-fifths of a revolution and the torque is nearly as good as in a six-cylinder engine. The balance is said to be practically perfect. The cylinder cooling arrangements are an interesting feature of the engine, and in Figs. 7 to 14, on page 626, we give various detail illustration of the arrangement. There are a series of jackets, disposed about the cylinders, through which air is drawn by means of a centrifugal fan which also forms the flywheel.

An elevation of the engine showing the air jackets, or ducts, in position is given in Fig. 7; while a cross-section showing part of the engine with the fans and its connection to the ducts is shown in Fig. 8. A development of the air ducts and cylinders is given in Fig. 9, which affords a clear idea of the whole arrangement. It is particularly claimed for this system that absolute uniformity of cooling of all surfaces of the cylinders and combustion chambers is attained. It will be obvious that this air-cooling system depends in no way for its efficiency on the movement of the car through the air. It is purely a function of engine revolutions, and the faster the engine runs the greater the supply of cooling air. As will be clear from Fig. 8, the fan, which is also the flywheel, is of comparatively light construction. This has been rendered possible owing to the movement of the radial connecting rods giving a considerable flywheel effect. Various details showing the construction of the air ducts are given in Figs. 10 to 14, on page 626.

All sections of the cylinders, combustion chamber heads and valves are circular, and in consequence there is no distortion due to unequal expansion. This arrangement has been made possible by the use of concentric valves, which are one of the special features of the engine. A section and plan of the valve gear are given in Figs. 15 and 16, on page 626. As will be seen, the valves are in the form of sleeves working one inside the other, and with taper seatings. They are operated by overhead rocking levers actuated by tension rods from a camshaft placed in front of the engine. The cylinders are of steel and the cylinder heads of aluminium. They are screwed one on the other, as shown in Fig. 15. An important point is that, owing to the arrangement of the valves, this screwed joint is exposed only to exhaust gas pressure and not to explosion pressure. This should facilitate the handling of the engine by a layman. The reason for the protection of this joint from explosion pressure will be clear from Fig. 15, in which it will be seen that the exhaust valve seat is inside the screwed joint. The centre sleeve forms the inlet valve. The boss, forming part of the detachable head, which projects into the centre sleeve carries three piston rings, as will be seen from the figures. These form the gastight joint, and have the advantage of permitting a little latitude in replacing the head after removal, no very considerable accuracy of adjustment being necessary during such replacement. By undoing six nuts this detachable head may be at once taken off and the valve removed. This also allows the top of the piston to be got at for cleaning. The valves are both balanced, and as the exhaust valve does not open against terminal pressure, a light operating mechanism only is required.

The lubrication of the engine is novel. An oil tank is provided separate from the engine and a duplex oil pump is fitted. One side of this pump sucks oil from the external tank and forces it through the hollow crankshaft, from which it passes to the other bearings requiring lubrication. Any residue oil is taken by the other side of the duplex oil pump, which sucks such oil from the crank-case and returns it to the oil tank. There is thus no accumulation of oil in the crank-case and none flows into the bottom cylinder barrels when

the engine is at rest. Any oil thrown into the bottom cylinder barrels when the engine is in motion is shot out by the upward motion of the pistons, and it is stated that there is no trouble due to sooting-up of plugs in the lower cylinders. The second side of the duplex pump, which acts as a scavenging oil pump, performs also another function. It is used to force the petrol from the petrol tank, which lies very low in the frame, to the carburettor, which is considerably higher up. This function is made possible since the scavenging oil pump returns to the oil tank a considerable amount of air as well as oil. If the oil tank is fitted with an airtight cap an air pressure is quickly formed inside. This pressure relieves the oil pump proper from any suction duty, since the oil is actually forced to the pump. The forcing up of the petrol to the carburettor is arranged by carrying a small diameter pipe from the top of the oil tank to the top of the petrol tank. This clearly gives a supply of compressed air on top of the petrol, and the result is a remarkably simple forced-feed system. A relief valve is fitted to prevent any undue pressure accumulation. A hand pump is fitted for starting. We understand that this very simple and pretty arrangement is patented.

A further point in connection with the engine which should be mentioned is that it is mounted on a bulkhead, and that by removing a number of bolts in front of the flywheel housing the cylinders as a whole may be rotated for convenience of access to any one cylinder for inspection or repair. Transmission is by means of a multiple disc clutch to a three-speed and reverse gear-box which has the change-speed lever mounted centrally upon it. The rear axle is of the semi-floating pattern, with spiral bevel drive connected to the gear-box through a propeller shaft enclosed in a torque tube. The general lay-out of these details can be seen in Fig. 17. The road wheels are of the disc pattern, with tyres 810 × 90. Brake drums are fitted to the rear wheel hubs, the brakes which operate on them being controlled by a foot pedal. In addition, a powerful brake is fitted at the rear of the gear-box and is coupled up to the hand lever. This is looked upon as an emergency brake and also for holding the car when stationary. The hub brakes are the normal service brakes, and the emergency brake, owing to its higher speed, serves as a more rapid-acting stand-by for use when necessary. Steering is by worm and quadrant, and to facilitate getting in and out of the driver's seat the steering wheel may be tilted, as shown in Fig. 18. The car is not fitted with an electric self starter, purely on the score of weight considerations. Such a starter weighs from 60 lb. to 80 lb., whereas the engine itself weighs but little over 100 lb. Experiments are being carried out with a mechanical self starter, operated from the driver's seat, which does not weigh more than 10 lb. or 12 lb., but the starter is not at present fitted to the car.

THE INSTITUTION OF CIVIL ENGINEERS.

Presidential Address of Sir John Purser Griffith, M.A.I.

An engineer can have no greater reward at the close of a long professional life than to be conscious of the goodwill of his professional brethren. By the nomination of the council to the position of president of this great Institution, and your subsequent confirmation, you have conferred upon me what I consider the greatest honour an engineer can receive. I am grateful for it, and thank you. It was with considerable hesitation, on the grounds of age and residence so far from London, that I allowed my name to go forward for nomination. I sought the advice of those most competent to give it. They have made little of my fears, while on all hands, including Dr. Tudsbery, I have received the kindest assurances of support and help to make up for my personal deficiencies. I therefore came to the conclusion that it would be ungracious to decline the great honour you have conferred upon me. I recognise that I have also a responsibility to Wales, my native land, and to Ireland, the land of my adoption, which I have represented on the council for so many years, and where the whole of my professional life has been spent. I accept what you have done for me as an honour conferred on Ireland, which, with all her faults and failings, grows dearer to you the longer you live there.

It has fallen to my lot to occupy the position of president at a unique period of the world's history, and of our own beloved Institution. The greatest war has been waged, the greatest victory has been won, and, let us hope, the greatest and most enduring peace has been declared. We have closed the first century of this Institution's existence with gratitude, and embark upon our second century with hope. I wish it was possible for me this evening, in the time at my disposal, to place before you a condensed summary of the part which our profession has taken in the world's progress in the past century, of the share taken in the great war by the Institution and by the engineering profession in its many branches and ramifications.

We meet together to-day with hearts filled with thankfulness that the great war is ended, that the victory has been won, that peace is restored. We meet with hearts filled with gratitude and admiration for the part taken by all classes in the Institution in this great struggle for right and freedom, and we think with mixed sensations of sorrow and pride of the lives so freely laid down in their country's cause. Members of all classes to the number of 3,127, or 36 per cent. of our numerical strength, were called to service in either the Navy, Army, or Air Force. Every class—honorary members, members, associate members, and students—is represented in the Roll of Honour. We hope to be able to erect in these premises a worthy memorial of "our glorious dead." I cannot describe them better than by quoting the words of the Dean of Westminster at the Memorial Service last June :—

"They were men drawn from posts of great responsibility and high scientific distinction. They surrendered to the service of their country the gifts of their industrial skill, and the riches of their professional experience. In every field of warfare—by sea and land and air—they have won an honourable immemorial record of great achievement. They were the pride of their homes. They went out in the beauty of their strength and manhood. Their sacrifice has been the price of their country's complete and final triumph."

While our thoughts naturally dwell on those who laid down their lives for King and country, we must not forget the survivors. Over 10 per cent. of those mobilised laid down their lives, and amongst the 90 per cent. who survive, many have been maimed or disabled. We tender to them our sympathy and grateful thanks, and rejoice that their lives have been spared. We also congratulate those who have returned unharmed to homes and friends and useful lives. Is it too much to hope that the experience gained by them as leaders of men in this great war will bring forth fruit in making them leaders of men in the great works of peace and reconstruction which lie before us?

There is another section of our members whose quiet, useful and unobtrusive work is apt to be forgotten. I refer to those senior members whose age prevented them from active service. Many of them placed their mature experience and technical knowledge unreservedly at the disposal of the Government. Their work is known to few, and often has not been officially recognised; but their greatest reward is the knowledge that they have done their best to hasten victory and peace, and that this great Institution to which they belong is proud and grateful for their services.

In entering the second century of our existence as a Society or Institution of Civil Engineers I wish it was possible for me to review the aims of its founders, and show you how far these have been attained. Time, however, does not permit me to do more than to point out that the best definition of these aims is given in the Charter of the Institution, dated June 3, 1828, in the following words :—

"For the general advancement of mechanical science, and more particularly for promoting that species of knowledge which constitutes the profession of a civil engineer, being the art of directing the great sources of power in Nature for the use and convenience of man."

I feel I am safe in saying that this Institution has faithfully carried out these objects. It has also formed a bond of union for its members scattered over the world. It has endeavoured to raise the standard of professional education and to stamp its students and corporate members with the hall-mark of professional efficiency and honour. It has, through its Benevolent Fund, endeavoured to hold out the helping hand to its members in times of need, and to visit their fatherless children and widows in their affliction.

Dr. Tudsbery, in his "Record of the Origin and Progress of the Institution," prepared for the Centenary Commemoration of its foundation, has succinctly recorded the steps taken to carry out the objects of its founders of "facilitating the acquirement of knowledge necessary in the civil engineering profession, and of promoting mechanical philosophy." He has shown the advantages gained by its formation, how it gathered together the ablest and best engineers of the country, who, although trained and brought up in the school of individual and independent action and experiences, yet were led to recognise the need of co-operation and combination to ensure the progress and success of the profession to which they belonged.

In this connection we should remember the valuable work done by some of our members in what may be termed research work. Committees have considered and reported on such subjects as :—

The thermal efficiency of the steam engine.
The standardisation of engineering materials.
The use of reinforced concrete.
The deterioration of structures exposed to sea action.

The last committee is still sitting under the chairmanship of our revered past-president, Sir William Matthews. He has formed in this building a unique collection of samples of injurious action by marine life and sea water on various materials from all parts of the world. Arrangement have been made for very extended series of experiments, and when completed the information gained by this committee will, I believe, be of immense value and importance to engineers engaged on marine works.

These aims and objects of our Institution are worthy of our united exertions to further and advance. We must not be content to reap the harvest sown by the great engineers who founded it, but endeavour to mould it and guide it so as to meet the requirements of its ever-widening field of operations.

It is not to be wondered at that we occasionally hear complaints, more or less articulate, tending to belittle the usefulness of our Institution, such as :—

"What is the advantage of being a member of the Institution?"

"What compensation do I receive for the payment of the annual subscription, and for submitting to the ordeal of seeking admission to its membership?"

"How can the interests of engineers scattered in the provinces and throughout the world be safeguarded by an Institution controlled by a comparatively small number of senior engineers resident near London?"

Perhaps I may be allowed to speak with perfect freedom on the subject, being a provincial member. There is no doubt that residence near London is of considerable advantage to a member of the Institution. London is the home of the Institution, and this building in which we meet to-day is the centre of our Institution's work. The privilege of attending its meetings, and taking an active part in its proceedings, and the use of the library are practically reserved for those classed as resident members, residing within a limited radius from the General Post Office of London, and there is also the overwhelming advantage of mutual intercourse and personal contact. These advantages are officially recognised by the different rates of subscription paid by what are termed resident and non-resident members, associate members, associates and students.

It is only just and fair to point out that efforts have been made to widen the control of the Institution by the inclusion on the Council of Engineers representative of the provinces, of the Dominions overseas, and of India. However desirable such representation may be, it must be borne in mind that the personal attendance of provincial members of council involves a considerable tax in time and money. This naturally leads to bad attendance on their part, and to placing the real control of the working of the Institution on members resident near London. It therefore seems to me that if the desire often expressed of increasing the proportion of the provincial members on the council were carried out, it might defeat the object aimed at by placing the real control in the hands of a small minority resident in or near London.

My experience has led me to the conclusion that regular attendance at council meetings is of great importance, and that any large extension of provincial representation would only weaken the council's influence and usefulness. While deprecating too large a representation on the council of provincial or Colonial engineers, there can be no question that the representation of the Colonies and Dominions, and the formation of Advisory Committees in these distant lands, has proved of real advantage to our Institution and engineers generally.

Although filled with admiration of the broad lines upon which this Institution was framed, we must not shut our eyes to the changes which have taken place in the status of our profession. The field of our members' work is now world-wide. The membership of all classes, which was 156 when the Charter was granted on June 3, 1828, exceeded 9,000 before the war, while the subjects dealt with by the civil engineer have multiplied with every advance of scientific knowledge.

The means of communication and transport by roads, railways, tramways, steamships, and aircraft have increased and advanced by leaps and bounds. The well-being of the great centres of population has called for the assistance of our greatest engineers for the water supply and drainage of towns. The need of improved intercommunication has led to the utilisation of electricity, for cables, telephones and wireless telegraphy, while the demand for economic distribution of power has been productive of advances in hydraulic, pneumatic and electrical transmission of energy. All these advances have depended for their fulfilment on the constructive ability, combined with the scientific knowledge, of the engineer.

It stands to reason that in the face of the numerical increase of our members, their world-wide influence, and the ever-extending field of their services, the scope of our Institution's duties and activities must expand. It is our duty to endeavour to make this Institution as useful to its 9,000 members as its founders made it for the 156 members on its roll when it received its Royal Charter. If we accept this view, we must listen to our members when they put forward proposals in what they believe to be the interest of our professional corporate life, and be prepared to consider and carry them out, if we feel that they will strengthen the bonds of professional brotherhood, although they may appear to conflict with our conservative traditions.

Two questions of importance to our Institution and to our profession have thus come before your council during the past year. The first is the desirability of forming local or provincial associations of corporate members for mutual intercourse, and the furtherance of their professional knowledge and interests. The second, whether the time has come for seeking legal recognition of the profession of the civil engineer, and the registration of engineers.

Local Associations.

The case in favour of the formation of local associations in union with the Institution has been brought under our notice by an influential deputation of members from the Midlands, who presented their case in a conciliatory and friendly spirit. The desire for local associations, recognised by the Institution, appears to be a natural and reasonable development of the student associations, already established in Glasgow, Manchester, Birmingham, Newcastle-on-Tyne, Yorkshire, Bristol, the West of England, and South Wales. The success of these student associations is undoubted. They have taught our young men the advantages of professional intercourse, both from its social and professional side. At the age of 26 the student ceases to be a member of the association, and if he wishes to retain his connection with the Institution must seek admission as an associate member. In this manner a large number of corporate members, scattered throughout the country, cease to gain the advantages of association which they had as students. This, I think, explains the present craving for the formation of local associations. I cannot help

feeling that their formation will be a distinct gain to the Institution, if the links binding them to the parent Institution are wisely forged. We must bear in mind that our membership is close on 9,000 in number, that our minutes of proceedings, in more than 200 volumes, contain some 4,239 papers, or an average of some 50 papers per annum, not more than half of which can be read and discussed. It seems to me quite clear that we are therefore not sufficiently in touch with the work of our members, and that the formation of local associations would lead to the presentation to them of many papers of special, personal, or local interest. I know nothing more useful and stimulating than such papers when criticised by local knowledge. In support of this proposal, allow me briefly to tell the story of the Institution of Civil Engineers of Ireland, with which I have been connected for the past forty-eight years. It seems to me to bear upon the present proposals for the foundation of local associations. The following quotation from my address as president to the Institution of Civil Engineers in Ireland, thirty-two years ago, will perhaps best explain its origin, and the motives which led to its foundation :—

"On August 6, 1835, 20 engineers practising in Ireland met at the Office of Public Works in the Custom House of Dublin, for the purpose of forming a society of civil engineers. At their first meeting, Colonel John Fox Burgoyne was called to the chair, and in his opening address he pointed out the objects aimed at. I cannot do better than quote his words : 'You are well aware that, in spite of the efforts of many able and eminent men, the profession has been at a low ebb in Ireland. Persons without education or skill have been frequently employed in operations of importance, and the consequence has been, as might have been anticipated, bad or injudicious works, wasteful or fruitless expenditure. It will be your effort to prevent the recurrence of these evils, and you are now adopting the measure best calculated to enable you to do so with effect, by organising a society for your own improvement. . . .

" 'Let us not overlook another essential benefit to be derived from such societies, namely, that they encourage harmony and kindly feelings of fellowship among men of the same class and mitigate dissensions.'

"The name adopted was The Civil Engineers' Society of Ireland. It embraced in its member class civil engineers, military engineers, and architects engaged as such in the United Kingdom ; and amongst its first members were Colonel John Fox Burgoyne, John Radcliffe, Richard Griffith, and Charles Blacker Vignolles —names which have become household words among us. Most of the members were scattered through the country, and the meetings were only held half-yearly at the Custom House. From 1837 to 1844 no reference appears of the proceedings in our minute book. In the latter year a meeting was summoned to determine whether the society should be continued or not. We rejoice to-day that there were men connected with it who, in the face of much discouragement, resolved that it was 'expedient to maintain the Institution, and to place it on such a basis as might render it permanently useful.' This resolve was followed by the adoption of new rules for the management of the society, and at the same time the name was changed to The Institution of Civil Engineers of Ireland.

"The progress of the Institution was now steady. The number of its members increased ; its meetings were frequent ; useful papers were read, giving rise to interesting discussions. Moreover, the publication of the Transactions was begun, and by this means the interest of members scattered throughout the country was increased. Under the new by-laws architects were no longer eligible for election as members."

It is important to bear in mind that the men who founded the Institution of Civil Engineers of Ireland were loyal and attached members of this Institution. It was founded in no spirit of hostility, but from a sense of the need for closer association of engineers at work in Ireland, which could not be provided by the Institution in London. I can, from personal knowledge, say that we have had no more loyal members of this Institution than those who, since 1835, have taken an active part in the work of the Irish Institution. Almost every past-president of the Institution of Civil Engineers of Ireland has been a member of this Institution, and three of them you have honoured by electing them your presidents.

In support of the advantages of local associations I should like to refer to what has been done by our members in New Zealand. This can best be gathered from a letter written by Mr. Robert West Holmes, I.S.O., our Member of Council representing New Zealand, and addressed to Dr. Tudsbery in August, 1917. In it he writes :—

"New Zealand is strictly a democratic country—a condition fostered, no doubt, through the absence of ancient institutions, customs and habits ; consequently there is a natural desire to found local institutions in support of many objects.

"It therefore became the desire of a large number of engineers to establish a New Zealand Society of Engineers, without any intention whatever of entrenching upon the field of action of the Institution of Civil Engineers.

"The movement was started by a number of local Government engineers, most of whom lacked the necessary qualifications for membership of the Institution, but who for the most part were capable men, doing very good work in their positions. The number who joined, however, was not sufficient to make a financial success of the society and at the same time to make an adequate return to the members, so I invited all the local members of the Institution to meet me and discuss ways and means of assisting the existing young society and generally improving the position of civil engineers in New Zealand. At this meeting it was decided to invite the support of all members of the profession throughout the Dominion, with the result that a large percentage of support was given towards the formation of a New Zealand Society of Civil Engineers. This took concrete form in due course, and with it the Local Government Engineers' Society was asked to, and did, amalgamate.

"The society has made considerable progress up to the present, since its foundation in 1914, which may be judged from the volumes of Proceedings which are contributed to the Institution's library. The war, however, as might be expected, has hampered our work through so many being absent with the military forces.

"The great work which the society has in hand, and which I am doing my best to assist, is the passing of legislation making it illegal on the part of Local Government authorities to expend public funds upon works unless under the supervision of a properly-qualified engineer.

"This will have the immediate effect of improving the position of the engineer, improving his education, and, in a large measure, saving the country the heavy loss incurred annually through the employment of incompetents. This legislation will also have the effect of assisting the Institution, membership of which is now looked upon as the hall-mark of the engineer, and is always advanced as a qualification for employment and a certificate of ability. Membership of the Institution is one of the qualifications which it is proposed to accept in the legislation referrred to.

"It will be my duty to inform the council as to the progress made in connection with the proposed legislation.

"In conclusion, I trust that the foregoing remarks may be of interest, and that they may be taken as a measure of my endeavours to facilitate engineering education, to improve the status of the profession, and to promote the interests of the Institution."

I hope these examples of local associations and their working will dispel any fears which may exist as to their being in any sense detrimental to the interests and prosperity of the Institution. Our aim, I think, should be to assist in the formation of federated societies or associations in preference to institutions completely independent. Such federated societies would keep the Institution in touch with the needs and wishes of our provincial or Colonial members, and would form useful agents for propaganda work in the best interests of the profession.

I well remember a case in point when the subject of standard tests and specifications was brought before the Institution of Civil Engineers of Ireland in 1887, and translations of the German standard specifications for Portland cement and structural iron work were printed in its Transactions in 1889. This was some twelve or thirteen years before this Institution took action and formed the Standards Committee under the guidance of Sir John Wolfe Barry. Meanwhile the seed had been sown and the ground of engineering opinion prepared for the great work undertaken and so successfully carried out by the Engineering Standards Committee.

Legal Status of the Profession of Civil Engineering.

There is a second problem with which we are faced. Has the time come for some legal status to be sought for the profession of the civil engineer, not only in the interest of the civil engineer, but also of the public at large ? The founders of our Institution hoped and expected that membership of the Institution would become the recognised stamp of the trained civil engineer, and that the public would thereby be protected and enabled to select fully qualified men to undertake the design and construction of public works. It is a curious coincidence that these problems of recognition and registration, which are occupying our attention now, were also under consideration when, thirty-two years ago, I read my address as president of the Institution of Civil Engineers of Ireland. The following quotations will, I think, be of interest :—

"Our profession owes its high position chiefly to the labours of individuals, and we gratefully recognise our obligations to them ; but the conviction is pressing itself on many thinking men that the time has now come for more united action on the part of the profession at large. You are probably aware that efforts are being made to obtain an Act of Parliament for the registration of qualified practitioners in architecture, civil engineering and surveying. The object of this movement is to enable persons requiring professional aid to distinguish qualified from unqualified practitioners. We should gratefully hail a satisfactory solution of this difficult problem. It should, however, be grappled with by the recognised organisations of our profession, and not left to individual action. Assuredly if we do not take the matter in hand, outside influence will be brought to bear, and unwise legislation may follow which it will be difficult to undo.

"The words of Sir John Burgoyne are still too true : 'Persons without education or skill have frequently been employed in operations of importance, and the consequence has been, as might have been anticipated, bad or injudicious works, wasteful or fruitless expenditure.'"

"In Ireland there are special inducements for qualified persons to call themselves 'civil engineers,' and the letters 'C.E.' after a man's name are of themselves sufficient justification for grave suspicion as to professional qualification."

In the year 1886 the Council of the Institution of Civil Engineers appended the following note to their annual report :—

"The use of the simple letters 'C.E.' is expressly discountenanced by the Institution, as not founded on any qualification and as being calculated to mislead."

Our by-laws enjoin on all classes of members the use of the official designation, M.Inst.C.E., Assoc. M.Inst.C.E., &c.

The Architects, Engineers, and Surveyors Bill referred to was opposed by this Institution, and withdrawn by its promoters before its second reading. The grounds of the opposition of the Institution are set forth in a statement of the council against the second reading of the Bill. They are to be found on pages 176 to 178 of the ninety-fourth volume of the Minutes of Proceedings. This statement formed the basis of the petition to the House of Commons, which was duly presented by Mr. Alfred Giles, M.P., then a vice-president of the Institution. A generation has since passed away, and we are again face to face with the same problem. Your council recently decided to test the views of the corporate members of the Institution, and submitted the following form of inquiry to those resident in the United Kingdom :—

"I ——— approve of the Institution of Civil Engineers taking steps to obtain statutory powers to prescribe the qualifications and to conduct examinations for admission to the profession of civil engineering, to keep a register of civil engineers, and to prevent persons who are not duly qualified from holding themselves out as members of that profession."

Ninety-seven per cent. of the replies were in the affirmative. That I view as a distinct direction to seek the necessary powers. It is not claimed or intended that every qualified civil engineer must be a member of this Institution, but that no one should claim to be a civil engineer without being suitably and legally qualified. We do, however, desire that membership of this Institution shall be an undoubted proof of the highest qualifications.

Labour-Aiding Appliances and Output.

Three years ago it was my privilege to submit for your consideration, in the twenty-fourth James Forrest Lecture, some of the economic problems in connection with the handling of raw materials and merchandise at ports and other large centres of traffic. In putting forward the plea for the efficient equipment of our ports and traffic centres I endeavoured to show that the old term "labour-saving appliances" should be replaced by that of "labour-aiding appliances," because we do not aim at reduction of employment, but at a greater individual output. I little thought when speaking to you how soon this problem would have to be faced in an acute form. The great war has left us a heritage of unrest and unprecedented taxation. Increased cost of living due to the war led to demands for increased pay. The need was recognised by the Government and the nation at large. Increased pay was granted broadcast ; war bonuses followed in rapid succession, generally granted with the reservation "for the duration of the war" ; and, with the declaration of the armistice, the out-of-work donation was invented.

Can we not see, and get all classes to see, that unless we alter our methods, mere increase of wages means increased cost of production, and increased cost of living ; that unless output is increased we shall move in a vicious circle, and there will be no real permanent improvement in the condition of our people ?

The "unrest" which is so widespread is, no doubt, due to the suspicion that the workman is not getting a fair share of the revenue derived from industry. The declaration of large dividends, and the tax on excess profits, have led the employee to believe that he is not receiving his fair share of the earnings, and the lack of comradeship and confidence between masters and men increases the suspicion, which takes the place of trust and friendship which should exist in our industrial life.

Let me take the case of Ireland, as showing some striking examples of the severance of the bonds of friendship, which at one time existed, uniting the landlord with his tenantry, and the industrial master with his men. I have one strong objection to the Act of Union, which abolished the Irish Parliament. It led to the migration of the Irish landed proprietors to Westminster. There they had to live amongst a wealthy English aristocracy. The spirit of emulation and pride resulted in extravagant living. Money had to be found, estates were mortgaged, the resident landlord became an absentee, and was replaced by the resident agent. With every improvement effected by the tenants, rent was raised, and the land war, with all its tragic misery, followed. The transfer of the land to the tenantry has been the only successful remedy ; but, unfortunately, it has only been half done. Wherever completed, the face of the country has been transformed, but the friendly relationship has not been restored.

In industrial life there has also been the severance of masters and men. I am old enough to remember many cases of paternal government and control in industrial concerns, where the master lived amongst his people, was in personal touch with them, knew their circumstances, their sorrows and their joys. The introduction of the Limited Liability Companies Acts brought this condition of industrial life practically to an end. The personal proprietor was replaced by the company and board of directors, and the personal touch of the owner was replaced by the manager, whose interest it was to increase dividends for the shareholders. The severance of the master from his men was complete. Trade unionism followed, for the men had to look after their own interests, apart from the interests of their masters, or of the industry on which they depended for their livelihood. There are, of course, bright exceptions to this dark picture ; but the exceptions bring the rule into stronger relief.

What can be done to put an end to such a state of affairs, which amounts to civil war, and to restore industrial peace and prosperity ? It appears to me that the only remedy is a wide adoption of co-operation,

co-partnership, or profit-sharing, which will ensure the workmen's participation in the prosperity of the industries in which they are engaged. Such things have been done. Why cannot they be extended broadcast through our industrial system?

Let me refer to one example upon which I like to dwell, because its initiation and success have been largely due to members of this Institution. It is that of the South Metropolitan Gas Company. A report of its last ordinary half-yearly general meeting appeared in *The Times* of August 14, 1919, and I should like to quote a few words from the address of the chairman, Dr. Charles C. Carpenter, a member of your council, and also of Mr. Honoratus Lloyd, K.C., an associate of this Institution. Dr. Carpenter, in proposing the adoption of the report, said:—

"For close on thirty years the supply of gas to South London has been unimperilled by any suggestion of a strike among the company's employees.

"Through all the trying times through which we have been and are passing, our employees have never wavered in their loyalty."

Mr. Honoratus Lloyd, in seconding a further resolution, said:—

"At present we are under the grave disability of having to pay high prices for our coal, and may I echo the pious hopes expressed by the chairman, that none of us may live to see the nationalisation of coal? What we want to see is that everybody who has an interest in coal gets his fair share of the profits. Let the capitalist have his fair return; let the hewer have his fair share, as represented by his work. And can you have any more successful way of doing it than by having—call it profit-sharing, co-partnership, or what you may—a system which results in each man having an interest in his own work, and in that of his gang or his mates, just as the capitalist has in the return on his money?

"I only wish that those who sat on the Coal Commission recently could have visited us down at the Old Kent Road, and seen our board, constituted of representatives of capital and labour, and the harmonious way in which they work together. The men's representatives have every opportunity of seeing every account. They are able to go through every receipt, and to take part in signing cheques, knowing exactly how we stand, and how we do things. It is that which gives us our strong position; it is that which enables us to carry on as we have done, and as we shall do. And I am quite sure that, whether the men on the Board be representatives of the shareholders or representatives of the men, we shall continue to work in harmony, and provide that commodity which our customers require and shall have."

Is not that a state of affairs which should pervade every industry in our land? Is there any reason why it should not? I know that I shall be told that, however applicable such co-partnership or profit-sharing may be to gas undertakings, it is not applicable or possible in such and such industries. I shall be told that it has been tried and has failed in such and such a case; that the trade unions will not agree to its adoption. I freely admit the different conditions under which various industries are carried on, and the difficulty of dealing with such cases as shipbuilding and dock labour, but I cannot believe that it is past the wit of man, especially of the engineer, whose life work is the solution of problems and the mastering of difficulties, to devise some system of co-operation which will lead to industrial peace and goodwill. The failures that I have met with have been due to distrust. I believe that distrust can be overcome by open and above-board dealings. It is in this direction that we as engineers have, I believe, special opportunities for breaking down the class barriers which have been erected, separating masters and men. Those of us who have had the privilege of personally carrying out work with our own men know that it is possible by fair and honest dealing to gain their respect and confidence. Our mission should be to demonstrate to them, in season and out of season, the absolute necessity of increased output in their own interest and that of their employer, and the future of their country.

Engineering in Ireland.

You probably expect me to make some reference to what our profession has done in Ireland. The story of engineering achievements in that delightful land is one of the brightest spots in its sad history. If religious intolerance and political trickery and intrigue could be banished, and the land handed over to the guidance and control of engineers, what prospects would be opened up of industrial progress and contentment? We need only consider what has been done by our profession in the face of all the turmoil and distress which infest our land to come to the conclusion that under favourable conditions Ireland would be one of the most prosperous agricultural and industrial countries in the world.

Is it not a striking fact that this small Emerald Isle was the birthplace of:—

The largest telescope,
The largest ships,
The largest sluices,
The largest concrete blocks for harbour work,
The most striking improvement of a harbour entrance by artificial scour;

and that in industrial factories Ireland can claim:—

The largest brewery,
The largest linen, spinning and weaving works,
The largest rope works;

while in railways, tramways and lighthouses she takes a high place?

The Largest Telescope.

The story of the great telescope constructed and erected at Birr or Parsonstown in the centre of Ireland by that great engineer and astronomer, the third Earl of Rosse, an honorary member of this Institution, reads like a romance. In the grounds of his castle he designed and constructed the great Newtonian reflecting telescope, which will ever be associated with his name. The tube was 7 ft. in diameter, and 53 ft. long, while the metallic reflector or speculum was 6 ft. in diameter. No telescope had previously been constructed of such a size. What seemed overwhelming difficulties were met with in the casting, tooling and polishing of the great reflector, but were overcome by this master mind.

I cannot do better than quote the words of the late Sir Robert S. Ball, Lowndean Professor of Astronomy and Geometry in the University of Cambridge, and former Astronomer Royal of Ireland:—

"I do not think it ever occurred to me to embark on an astronomical career until November 8, 1865, when I received a letter from Dr. Johnstone Stoney. It conveyed the following message: 'Would it be agreeable to you to act as tutor to Lord Rosse's sons at Parsonstown?'"

"The outstanding feature of Birr Castle, by which it will be for ever famous in the annals of science, is the mighty telescope. Between the lake and the castle are two great walls, which are now somewhat overgrown with ivy. I have been told that visitors entering the gates of the park for the first time have driven up to these walls in the belief that they are approaching the castle itself, which is not visible from the park gates. Between these two walls swings a tube 60 ft. long, and more than 6 ft. in diameter. At the lower end of this tube is the mighty mirror or speculum.

"Lord Rosse not only designed the great instrument, but actually constructed it. At the back of the castle he had extensive workshops where a capable smith named Coghlan and numerous assistants carried out the work under the direction of the Earl himself. It was he who devised methods of getting over the innumerable difficulties involved in casting, grinding and polishing the great speculum, which weighed over 3 tons. He had many failures before he achieved success; and the precepts which he laid down have been followed by all who have since made great reflecting telescopes.

"Lord Oxmantown, Lord Rosse's eldest son, was not one of my pupils. They were his three younger brothers, who are now the Hon. and Rev. Randall Parsons, the Hon. Richard Clere Parsons—a well-known engineer—while the youngest is the Hon. C. A. Parsons. It has always been a great satisfaction to me to remember that I had the great honour of instilling the elements of algebra and euclid into the mind of the famous man who had revolutionised the use of steam by his invention of the steam turbine. It would seem that he inherited his father's brilliant mechanical genius, with an enormous increase in its effect on the world."

The use of the great telescope is thus described by Sir Robert Ball:—

"Nebulae were at that time objects of special interest. At the beginning of the century Sir William Herschel had completed his famous survey of such nebulous objects as were visible in the northern sky, while Sir John Herschel, in his expedition to the Cape of Good Hope, had completed the work which had been begun by his father. It was left to the Earl of Rosse to start from the point which these investigators had reached. His telescope was much more powerful than those which the Herschels had used. Indeed its optical and mechanical arrangements were as perfect as was possible in an instrument of this description. On the other hand, it must be remembered that Birr Castle is not an ideal place for an observatory. It is near the Bog of Allen. Consequently the skies are frequently overhung with clouds. Even Herschel himself in his observatory at Windsor had found that not more than 100 hours in the whole year were adapted for the purpose of the highest class of astronomical investigation."

The great telescope has done its work, and the grand reflector rests in the museum at South Kensington, a monument of untiring industry, perseverence and scientific research.

We have still in our midst the two youngest sons of Lord Rosse mentioned by Sir Robert Ball. They are brilliant examples of the value and influence of heredity and environment as a preparation for a successful engineering career.

The Largest Ships.

Wooden shipbuilding was begun in Ireland at an early date. It is not to be wondered at that it was a reasonably successful industry spread around the coast; but that the industry should develop in Ireland to the construction of the largest class of steel steamship is wonderful, considering that all the steel and the coal used have to be brought across Channel from Scotland or England.

The shipyards of Belfast turn out the finest and most up-to-date vessels in the mercantile marine, and the names of Harland and Wolff and Workman and Clark are familiar throughout the shipping world. Our fellow-member, Lord Pirrie, has not been content to limit the activities of his great firm to Belfast, but its branches or controlled establishments extend to Scotch and English ports. Steel shipbuilding is not, however, restricted to Belfast; Dublin, Londonderry and Cork are making progress in the same direction, and the advances have of late been marked.

The Largest Sluices.

The Stoney Sluice, which has now become so widely known, was first erected in Ireland, where examples are found at Belleek, the outlet of Lough Erne; at Ballinasloe, on the River Suck; and at Lough Allen, the headwater of the River Shannon. The value of this sluice consists in the ease with which sluices of great size can be worked, by the reduction of friction, through the application of free rollers between the sluice and its pier. From Ireland, the birthplace of its inventor, Mr. Frank G. M. Stoney, M.Inst.C.E., and the land of its first application, its use has extended to the Manchester Ship Canal; the Thames, at Richmond; the Clyde, at Glasgow; the Nile, at the Assuan dam; and the Panama Canal. These sluices are worthy memorials of the patience and perseverence of the distinguished Irish engineer who designed them.

The Largest Concrete Blocks.

The great concrete blocks used in the North Quay Extension of the Port of Dublin form another example of brilliant engineering practice. They were designed by the late Dr. Bindon Blood Stoney, F.R.S., M.Inst.C.E., the engineer of the Dublin Port and Docks Board, under whom I served as an assistant engineer for twenty-eight years. Those of us who had the honour of working under him, either as pupils or assistants, look back with intense admiration and reverence to his enthusiastic love for his profession, and the powerful intellect which he brought to bear on every detail of work which came to his hand.

The giant blocks used in the harbour work of the Port of Dublin were built above high-water level, and when sufficiently set were lifted and transported by a floating shears or crane, and deposited on a bed prepared by steam dredging, and levelled by men working in a large diving bell, entered through a tube fitted with an air lock. Each block contained more than 5,000 cub. ft. of masonry, and weighed about 350 tons. The same floating plant was used for laying similar large blocks for breakwater protection, and for the foundation of one of the lighthouses at the entrance to the harbour. In the work for which they were specially designed, these great blocks proved a complete success, both from the structural and economic point of view. Their use allowed the extension quays to be built without costly cofferdams or heavy pumping.

Dublin Bar Entrance Channel.

There is another striking feature connected with the Port of Dublin, which I do not like omitting from the category of Ireland's great works. It was carried out by the early engineers of the port, and stands as a monument of their genius. The formation and improvement of the entrance channel across Dublin Bar was the result of long and careful investigation by some of our greatest engineers. The construction of one of the largest artificial tidal reservoirs, and the masterly manner in which its outflow has been directed and regulated, so as to synchronise with the tidal currents in Dublin Bay, warrant me in claiming that it is one of the most striking examples of the use of tidal scour for the improvement of a bar harbour. Not only did these works steadily improve the channel across the bar, and keep its depth in advance of the dredged river channel up to the city for half a century, but when it fell to my lot to take advantage of modern suction dredging to increase more rapidly the depth of the bar channel, I found that I possessed in the great tidal reservoir an agency which promised to maintain the increased depth without any large expenditure on maintenance dredging.

Am I claiming too much when I say that the men who designed and carried out these works were engineers in the truest sense, for they thus utilised one great source of power in Nature for the use and convenience of man?

Large Factories.

Although Ireland is chiefly an agricultural country, yet along her sea front, especially her northern and eastern shores, industries have sprung up and become celebrated. These include the flax, linen and brewing industries. The Belfast Rope Works, and the York-street Flax-Spinning and Weaving Mill in Belfast, and Guinness's Brewery in Dublin, are examples of the largest factories in these particular industries. They have all called forth the highest engineering ability in their respective lines, and represent the greatest advances in their respective manufactures.

Railways.

In regard to Irish railways, it is interesting to remember that, in consequence of the waste of capital in England by the construction of competitive railways, the Government, towards the end of 1836, appointed a Commission to inquire into the manner in which railway communication could be most advantageously promoted in Ireland. Up to this time only one railway—that between Dublin and Kingstown—had been constructed in Ireland. The Commission was a strong one, consisting of Mr. Thomas Drummond, then Under Secretary of State for Ireland; Colonel John F. Burgoyne, Mr. Barlow, Mr. Richard Griffith, with Captain Harry D. Jones, as secretary. The Commission reported in 1838, and meanwhile all railway construction was held in abeyance. The report aimed at laying down a system of railways in Ireland, with a view of gaining the greatest advantage at the smallest cost, so as to guide Parliament in the choice of projects which might come up for consideration, and prevent the waste of capital. The report is one of extraordinary interest and value.

The death of Mr. Drummond, and the passing of the Government into the hands of a minister who held that enterprise should regulate itself, led to no State action being taken by the Government on this report. Railways were promoted by private companies, several of which departed from the lines recommended by the Railway Commission, and we know now that such departures have proved unremunerative and inefficient.

There is, however, on one of these lines a work of great historic interest. The railway connection between Dublin and Belfast was carried out by three companies—the Dublin and Drogheda Railway Company, the Ulster Railway Company, and the Belfast Junction

Railway Company. This trio forms part of the present Great Northern Railway of Ireland. The River Boyne is crossed by a lattice tubular bridge for a double line of rails. The bridge consists of three spans; the centre span is 267 ft. in length, and each side span 140 ft. 11 in. from centre to centre of bearings. The main girders are connected over the piers and form continuous girders 550 ft. 4 in. in length. It is, I believe, the first example of a continuous lattice girder, and is of special interest to me because my old chief, Dr. Bindon Stoney, was the assistant engineer under the resident engineer, Mr. James Barton. Mr. Barton read a paper before this Institution in 1855 on "The Economic Distribution of Material in the Sides and Vertical Portion of Wrought Iron Beams." In this paper he described the Boyne Viaduct and the method of determining the points of contrary flexure, and gives Dr. Stoney the credit for elucidating this method. The bold experiment of cutting out the rivets at the points of contrary flexure to test the accuracy of the calculations has always impressed me. I can imagine with what delight the future author of "The Theory of Stresses in Girders and Similar Structures" watched this practical test, and the complete vindication in practice of the theoretical consideration which governed the design.

Tramways.

Dublin United Tramways.—Ireland took the lead early in tramway construction, and the Dublin United Tramways system is one of the finest and best-managed tramways in the United Kingdom. It provides the city of Dublin and its suburbs with a most perfect means of intercommunication, extending around the whole girth of Dublin Bay from Howth to Dalkey. The whole system is worked from one power station in the city of Dublin. Its mileage exceeds 54 miles, and in 1918 it carried over 71,000,000 passengers.

The Giant's Causeway Electric Tramway.—There is a short line of tramway between Portrush in county Antrim and the Giant's Causeway, which, although but a small concern, is yet of considerable interest. It was constructed thirty-eight years ago, when electric traction was in its infancy and had in fact hardly passed its experimental stage. Mr. William Traill conceived the idea of utilising a waterfall on the River Bush, to generate electricity and apply it to working tram cars from Portrush to the Giant's Causeway. He communicated his ideas to the late Dr. Siemens, and, with the aid of Lord Kelvin, Sir Frederick Bramwell, Sir John Wolfe Barry, and others, formed a company to test this new and hitherto untried experiment of electric traction, worked from a waterfall, and thus inaugurated the pioneer hydroelectric tramway of the world.

Lighthouses.

It is my privilege to be a Commissioner of Irish Lights—a Board which has charge of the lighthouses, beacons and buoys around the coast of Ireland—and to take part with the Inspecting Committee in their annual tour of inspection.

There are many points of interest to an engineer who has been engaged in marine work in such an inspection. He meets with examples of early lighthouse practice, and is able to appreciate the gradual progress which has been made in lighthouse illumination, fog-signalling and buoyage.

As Ireland stands out in the Atlantic as a shelter or breakwater to the western coast of England and Wales, the lights on the west of Ireland are of supreme importance for the Atlantic trade between the United States or Canada and Great Britain. The principal lighthouses on the western coast are important land-fall marks, which vessels sailing eastward look out for. Their importance has been greatly enhanced by the high speed at which steamers now travel, and the necessity of long-range lights or fog signals is apparent.

I only propose referring to one of these principal light houses, the Fastnet. I do so because it has a particular fascination for me. Since the day I saw it, from the famous White Star liner Britannic, the first of the name, on my outward journey to New York in 1893, its position and appearance attracted me.

Mr. C. W. Scott, in his history of the Fastnet Rock Lighthouse, describes the Fastnet Rock as a pinnacle surrounded by deep water, about 4½ miles south-west of Cape Clear, rising to a height of 98 ft. above low water. It is seldom possible to land by stepping on to the rock from a boat, the usual way being by means of a derrick.

Formerly the light that guarded this part of the coast was on Cape Clear, but the outlying Fastnet Rock was found to be too great a danger to shipping to allow it to remain unguarded. It was therefore decided in 1848 to place a lighthouse on the Fastnet, and extinguish the light on Clear Island.

Mr. George Halpin, who was then the engineer of the Corporation for preserving and improving the port of Dublin—a Board which at that time was the lighthouse authority for the coast of Ireland—designed the first lighthouse. It was a cast-iron tower, 19 ft. in diameter at the base, and was fitted with a dioptric apparatus, exhibiting a white flash of 38,000 c.p. every 2 minutes, and a feeble fixed light from the upper and lower prisms. The focal plane was about 160 ft. above low-water level. During the existence of this first lighthouse considerable anxiety appears to have been felt as to the stability of both the tower and the rock itself. The advice of the engineers of the Trinity House and of the Northern Lighthouse Commission was sought, and it was decided to increase the diameter of the base of the lighthouse, and to fill up various chasms in the rock with masonry. The total expenditure on the lighthouse up to 1868 amounted to 27,000*l*.

In 1891 the Irish Lights Board decided that the light on the Fastnet was not sufficiently powerful for this important station, and, with the consent of the Trinity House and the Board of Trade, built the present magnificent lighthouse.

The site chosen was on the hardest portion of the rock, and the new tower was founded about high-water level, and carried high enough to allow of the focal plane of the new light being practically at the same level as the old light. The optical apparatus is a great advance on its predecessor, exhibiting a flash of 750,000 c.p. every 5 seconds. The work was designed and begun by Mr. William Douglas, M.Inst.C.E., then the engineer of the Commissioners, and carried to a successful completion in 1904 by the present engineer, Mr. C. W. Scott, Assoc.M.Inst.C.E.

Sir Robert Ball, F.R.S., the Commissioners' scientific adviser, concluded his report on the new Fastnet Light as follows:—

"In conclusion, I may say it is a matter of congratulation to everyone concerned that the Fastnet is now at length provided with a monumental tower, and a superb light, well worthy of the position of this lonely rock as being, from the navigator's point of view, the most important outpost of Europe."

Peat in Ireland as a Fuel.

The coal panic of the past few years has drawn attention to the unused peat deposits in the United Kingdom, and in 1917 the Director of Fuel Research (Sir George Beilby) and the Fuel Research Board decided to set up a small Committee of Inquiry into the utilisation of Irish peat deposits.

The committee was saved much labour and expense by being able to avail themselves of the valuable information obtained and published by the Bogs Commission, appointed by Parliament in 1809, "to inquire into the nature and extent of the bogs in Ireland, and to the possibility of draining and cultivating them."

The Bogs Commission consisted of some of the most distinguished men of the day, and the engineers employed to survey and report on the bogs were amongst the foremost professional men of the time. They entered fully into the nature and character and physical conditions of the Irish bogs, and were firmly convinced of the comparative ease with which the bogs could be reclaimed, and made a valuable financial asset of the country.

The evidence in the reports of the Bogs Commission proves that practically all the large bogs of the country can be naturally drained, without pumping, and without any great works of river improvement, and that the effect of systematic drainage would be to make the bog-lands available for tillage and peat winning, followed by the cultivation of the cut-away bogs.

It may naturally be urged that if the benefits are so great, it is difficult to understand why the work of draining the bogs has not been carried out long ago, and that there must be some fallacy underlying the proposal. The Bogs Commissioners in their fourth and final report, entered fully into this difficulty, and pointed out that it was not to physical obstacles that the condition of these wastes was principally to be ascribed, but to the indeterminate nature of the boundaries between adjoining properties and the rights of turbary and grazing claimed by the tenantry. Without special legislation, the problem bristled with difficulties.

It may be asked why the British Government did not take action on receiving such strong reports from the Bogs Commission, and bring forward legislation to carry out their recommendation. It might have got power to carry out the work itself, or it might have promoted legislation to remove obstacles, and assist in the work being carried out by individuals or private enterprise.

To understand the position, it is necessary to remember that at the time the Bogs Commissioners made their final report in 1814, British finances were exhausted as the result of the long Napoleonic War. Irish interests in Parliament were not sufficiently strong to carry such a measure through, and the interest of the British Government in Ireland was not sufficient to induce it to make such a sacrifice in her favour.

In addition, the effect of the Corn Laws agitation, and so-called free trade, discouraged home agriculture and the tillage of the land. No further steps were taken to reclaim the bogs of Ireland, and the valuable work of the Bogs Commission has been shelved for more than 100 years. Fortunately, its reports and maps have been carefully preserved in the archives of the Royal Dublin Society and the National Library of Ireland, and they were placed most generously at the disposal of the Irish Peat Committee.

Very large areas of Ireland are covered by its bogs estimated to amount to about 3,000,000 acres, more than one-half of which are "Red Bog" as distinct from "mountain peat soil." More than 1,000,000 acres of these bogs represent the flat and deep bogs, three-quarters of which are concentrated within the central belt, bounded on the north by a line joining Howth with Sligo, and on the south by a line joining Wicklow with Galway. It is estimated that the Irish bogs contain between 3,500,000,000 tons and 4,000,000,000 tons of anhydrous peat, or 5,000,000,000 tons of air-dried peat.

At present about 6,000,000 tons of peat per annum are burned as fuel in Ireland, and over 4,500,000 tons of coal are imported. If this coal were replaced by peat fuel at the rate of 2 tons of air-dried peat to 1 ton of coal, requiring about 9,000,000 tons of air-dried peat, the total consumption of peat in Ireland would be about 15,000,000 tons per annum, and the peat deposits would be sufficient to satisfy the fuel and power requirements of the country at the present rate of consumption for more than 300 years.

The Irish Peat Committee devoted much time and thought to the subject referred to them, and came to the conclusion that the reclamation of the bogs for agricultural purposes cold be successfully combined with the winning of peat for fuel, but that the introduction of mechanical winning and handling was essential.

In February, 1918, they reported on the subject to the Fuel Research Board, and after a conference with them sent in a supplemental report in July, 1918.

The Advisory Council, in their annual report, dated August 1, 1918, to the Lords of the Committee of the Privy Council for scientific and industrial research, made the following reference to the subject:—

"The Irish Peat Committee, which was appointed last year, recently presented a report which was considered by the Fuel Research Board, and subsequently discussed at a conference held in London between the committee and the Board in June of this year. As a result of the conference, the committee have now presented a supplementary report, which is under the consideration of the Board. The Board will in due course submit to the Committee of Council their views on this important and difficult question."

In their report of August 1, 1919, they make the following further reference:—

"The Fuel Research Board having given most careful attention to both the principal and supplementary reports of the Irish Peat Inquiry Committee, have submitted their views to the Committee of Council. The matter is still under the consideration of the Government."

The reports of the Irish Peat Committee, dated February, 1918, and July, 1918, together with the report upon them by the Fuel Research Board, have been in the hands of the Government since September, 1918, and nothing further has been heard of them. They now lie buried in some Government pigeon hole.

Water Power Resources of Ireland.

In June, 1918, the President of the Board of Trade, with the concurrence of the Minister of Reconstruction appointed a committee to examine and report upon the water-power resources of the United Kingdom, and the extent to which they can be available for industrial purposes. The chairman of this committee is Sir John Snell, and already a mass of interesting and valuable information has been collected, and an interim report issued for Great Britain.

In August of the same year it was decided to appoint a sub-committee to deal specially with Ireland. In one respect the Irish problem has an advantage over that of Great Britain, inasmuch as official inquiries in the form of Royal or Viceregal Commissions or Special Committees have been held, to report on questions of navigation and drainage connected with the principal rivers and waterways of the country, and an immense mass of reliable information is contained in their reports. The Board of Public Works exercises control or jurisdiction over several of the principal rivers and waterways, and its archives contain valuable information relating to them. With the assistance and co-operation of the Board and its officers this has been placed at the disposal of the sub-committee.

There are a great number of sources of power on the principal rivers, but in all such problems there is a conflict of interests to be met, such as navigation, drainage, fishing and existing milling rights. There is little hope of dealing thoroughly and economically with such problems unless they can be co-ordinated under some unified control, which can deal with them upon the broad lines of national utility.

Besides the large rivers there are hopeful sources of power in the mountain districts of Donegal, Connemara, Kerry, Wicklow and the Mourne.

An interesting and classical example of the utilisation of water power is to be found on the Upper Bann, where, under the advice of Mr. Fairbairn and Mr. J. F. Bateman, reservoirs were constructed to store and regulate the flow for the mills along the river. There are interesting papers in our early Proceedings and in the Transactions of the Civil Engineers of Ireland on these works.

With the advances made in electrical transmission, I look forward hopefully to a linking up of the scattered water resources in Ireland into a useful service to supplement our fuel resources.

Economy and Waste.

Economy is the cry of the present day, and the financial condition of the country needs economy. War is waste in every detail. Industrial strife, with its strikes and lock-outs, is waste. We sympathise and join whole-heartedly in every effort to stop this waste. There is, however, the great danger ever present that the nation may be side-tracked by this cry of economy from the paths of restoration, reconstruction, and progress. There is the danger that the word "economy" may become merely a party cry; and it is well to bear in mind that the mere stoppage of the expenditure of money may not be economy, but may result in real waste.

It is not economy for a nation to save expenditure by not developing its resources. It is not economy to cultivate competition at the expense of a large expenditure of unremunerative capital. It is not economy to allow our canals and waterways to become obsolete and derelict, when, if unified, controlled, improved and standardised, they could advantageously supplement our railways in the transport of certain classes of traffic. It is not economy to allow our agricultural lands to go out of cultivation, because we can get cheap corn dumped down into our country from foreign lands. It is not economy to allow our peat bogs to remain undrained and unreclaimed, when they might become a source of national wealth in food and fuel.

It is not economy to allow our water-power resources to run to waste, instead of using them to reduce our coal consumption, and delay the day, which is not far distant, when our coal supplies will be exhausted or unavailable, either by consumption or the increased difficulty of winning.

I think we should look the approaching exhaustion of our coal supply fully in the face. It may be 100 years or 200 years distant; but year by year the difficulty of winning will increase, due to the increasing distances of the coal faces from the pit mouth, the longer time the men will take to get to their work, and the shorter time they will spend at the working face. Output under these conditions must decrease, and price of coal rise. For these reasons the development of our peat and water-power resources is an urgent and pressing need.

Neither of these great problems can be dealt with unless the State takes action, and removes the obstacles which exclude the possibility of private development. Without strong and clear-visioned statesmanship, I fear the cry for economy will assist the Treasury in falling back on its old methods and pre-war cry of "*Non possumus.*" For this reason there is need for strong scientific financial control, capable of discriminating between waste and economic expenditure.

A National Western Harbour in Ireland.

What are the lessons of the war as regards Ireland? I think the principal lessons were its isolation, the importance of its strategical position, and the deficiency in harbours or naval bases on its western coast. It was around the coast of Ireland that the submarine menace was chiefly felt, and if a hostile fleet had got command of the sea near her shores, Ireland would undoubtedly have been used as a base against our oversea trade, and our food supplies would have been jeopardised. I often think, what Germany would have done with Ireland, if in her possession. It would have become a second and more powerful Heligoland. At present the western coast between our naval bases at Berehaven and Lough Swilly is unprotected. I am of opinion another naval base should be formed in Galway Bay, and a thoroughly equipped harbour built there. This harbour would be available in time of peace as a deep-sea fishing station, and also as a terminal port for a high-speed passenger and mail service between Canada and Europe, or the United States and Europe. The transit of the American passenger traffic through Ireland would be of immense advantage to the country by keeping Ireland on the principal thoroughfare of the Canadian and American traffic.

It is impossible to lay too much emphasis on the importance of keeping Ireland on this thoroughfare, and of passing passengers and mails through the country. It would bring Ireland into constant touch with the outer world, and reduce some of the injurious effects of its insular position.

By combining these defensive and strategic requirements with a scheme which would be productive of great commercial advantage to the country, I believe much would be done to unite Nationalists and Unionists, for there can be no division of opinion that the passage of the principal transatlantic mails and passenger trade through Ireland would be of overwhelming advantage to the country.

Ireland is the landing place of several Atlantic electric cables. Ireland has been a principal station for transatlantic wireless telegraphy. Ireland has been the landing place for the first transatlantic direct flight, and Ireland should be the principal "bridge-head" for the transatlantic passenger and mail traffic between America and Europe.

It is a difficult task which is laid upon an incoming president to review in some measure the fields over which our interests as engineers extend. To take up any one of the subjects which I have touched on in this address, and deal with it completely, would have occupied the whole time at our disposal. My aim has been only to touch upon each item lightly, and place them before you, to consider and think over at your leisure. By doing so a professional bond of thought and opinion will be formed, which will be of the greatest assistance to your council in furthering the best interests of the profession and of our Institution.

I have touched upon some samples of the work of our profession in Ireland, to show how successful honest endeavour has been in furthering its material prosperity. We have had noble examples of engineers in Ireland, who have given of their best for the advancement and prosperity of that land. I look forward with greater hope for the future of Ireland from the work of the engineer than from any political propaganda for the cure of imaginary wrongs.

I may be told that I am an old man who dreams dreams. I admit it; but the dreams I dream, and like to dream, are those which recall the magnificent work done by our profession in the past. I like to dream those dreams, because they act as incentives to further and greater endeavour. I like to tell these dreams to you young men, to lead you on to visions which are your heritage—visions of progress and reconstruction—visions of the body corporate, formed of its various members, capitalist, management and labour, working together for the building up of the edifice of a happy and contented people—visions of the new heaven and the new earth, wherein dwell justice, honesty, virtue and goodness.

SYNTHETIC CAST IRON.*

By Charles Albert Keller, Livet, France.

Part I.—Synthetic Cast-Iron, its Origin and Development.

"Synthetic cast-iron" is the term by which, since the commencement of its manufacture in the electric furnace, the author has always described the iron obtained by the recarburising melting of steel turnings. This term has since passed into metallurgical currency, and has now become generic.

The novelty of the manufacture of "synthetic cast-iron" consists in carburising iron and steel scrap, and more particularly turnings, by melting these materials in the presence of carbon, which is introduced simultaneously with them in the melting appliance. The electric furnace is plainly indicated as best fulfilling all the conditions required for the carrying out of this metallurgical operation.

From the outset of the manufacture of steel in the electric furnace there had been obtained, incidentally and without any practical importance being attached to it, the carburisation of steel to cast-iron composition. Apart from this, and indeed long before it, the process of carburising iron up to saturation point was well known. No advantage was, however, derived from these facts, as the carburisation of a bath of steel in a covered-in furnace, obtained by the various known methods of carburisation, such as the introduction of dense conglomerates of carbon and iron (carburite) or pressed blocks of carbon and cast-iron was only practised with the object of obtaining steel, and, moreover, these processes are neither convenient, practicable, nor economical when carburisation is carried to the extent of producing cast-iron. Only a process of continuous carburisation, effected during the course of melting a mixture of steel turnings and carbon,* could conduce to an economic method of producing synthetic cast-iron with a commercial future capable of development as other than a mere war emergency.

The preliminary melting of steel turnings in a bricked-in furnace necessitates, indeed, the consumption of an amount of energy corresponding with the temperature which has to be developed in order to melt the steel. It must further be remembered that the thermal efficiency of a furnace of this type is lower than that of an open type furnace constantly replenished with materials for melting, and the walls of which are much cooler. On the other hand, charging turnings into a closed-in furnace, with doors, involves technical difficulties. These disadvantages are, however, but small in comparison with those accompanying the actual carrying out of the carburisation in the two instances. The carburisation of turnings, after melting, can only be effected by solution brought about between the upper layers of the metal and the carburants. It becomes the more difficult, and the slower, the higher the percentage of carbon rises. The dense carburants employed are expensive, and the consumption of energy resulting from the slowness of the carburisation becomes considerable. As the furnace has to be emptied after each heat there must likewise be taken into consideration the heat losses inseparable from this operation, as well as the repairing of the hearth, sides and roof, none of which arise in the continuous running of an open furnace.

In an electric furnace charged with steel turnings mixed with carbon the carburisation is not only absolutely controlled by the known reactions of the substances present but, it should be noted, as an important economic advantage, that the combination of the carbon with the iron begins in the upper parts of the charge, long before actual fusion. Cementation intervenes from a temperature of 650 deg. upwards and becomes more rapid in proportion as the temperature rises, owing to the descent of the charge.

Carburisation of the iron takes place subsequently, by the contact between the solid carbon and the partially carburised metal in the course of melting, and becomes complete on full melting, the temperature of which is determined by the nature of the iron, so that casts can readily be obtained in the electric furnace at temperatures of 1,200 deg. to 1,300 deg. C.

The author has so far dealt only with the carburisation properly so called. The proper working of the process in the electric furnaces involves, however, other considerations. The mixture of steel turnings and carbon possessing, in itself, very high conductivity, it would become necessary, to ensure normal working in the electric furnace, to use so low a potential that higher currents than those ordinarily in use could be employed. On the other hand it would be a pity to employ electric fusion without profiting by the metallurgical advantages involved, in order to effect desulphurisation. The introduction of basic slag into the charge meets these two requirements and accomplishes two results, subsidiary and supplementary to the carburisation and necessary to the complete practical success of the process, namely:—

1. The lowering of the conductivity of the mass to be treated by the introduction of a non-conducing material amongst the conductive materials (turnings and carbon), thus enabling fusion to take place under ordinary thermo-electric conditions, and

2. Complete and easy desulphurisation of the resulting metal.

Thus carried out, the process may be described, from the metallurgical point of view, in the following terms:—

The iron obtained in the presence of a sufficiently basic slag, which combines with the small amount of silica introduced, will contain practically all the substances contained in the charge, except the sulphur. There will be no increase in the silicon, and the carbon in the charge will be used up solely in carburisation, without any appreciable intervention of the silica.

White cast-iron can thus easily be obtained with ordinary steel turnings. With turnings containing 0·44 per cent. of silicon, 0·55 per cent. of manganese, and 0·07 per cent. of sulphur a white iron of the following composition was obtained:—

	Per Cent.
Carbon	3·55
Silicon	0·52
Manganese	0·48
Sulphur	traces

Hence control of the percentages of silicon and of other elements becomes easy; for example, extra silicon will result from introducing more silica into the charge, along with a corresponding amount of carbon for reducing it. The percentage of silica in the slag will vary according to the percentage of silicon in the iron.

The certainty with which the above considerations can be relied upon allows of the process of manufacture described by the author being regarded as complying absolutely with the predetermined calculation of the charge, and as corresponding absolutely with the estimated amount of the elements contained in it. He can afford a proof of the truth of this conclusion by adducing an instance of an electric furnace with a capacity of 80 tons to 100 tons per 24 hours, which has not given rise, over a month's working and while specially watched for that purpose, to variations exceeding 0·25 in the results of carburisation and of siliconisation respectively.

It will have been thoroughly understood from what has been said that control of the composition of the slag must be strictly exercised; also that the amount of carbon introduced must be accurately known. The process being one of great accuracy, is correspondingly highly sensitive. It is necessary, therefore, to rely entirely on the help of the chemical laboratory.*

The carbon employed for carburising should correspond so far as its physical condition is concerned, with the size of the steel turnings, so that the contact between the particles may be as perfect as possible, and so as to facilitate carburisation in the higher portions of the furnace charge. Small coke is highly suitable, and so is wood charcoal. Either may be used, according to price and to the degree of purity sought.

The system that has been described is one of extreme simplicity. It does not require any skilled workman as the results sought are independent of any technical manipulation except in so far as the preparation of the charge is concerned, and depend entirely on an accurate knowledge of the composition of all the components.

The electric furnace, fed continuously by the charge, works regularly and with very small losses, as the heat transmitted by the electric hearth situated immediately beneath the charge is, to a very large extent, utilised in heating up the materials, and effects a preliminary carburisation prior to melting. This enables the consumption of electrical energy to be reduced to as little as 675 kw.-hours per ton of pig-iron in a 2,500-kw. furnace of 80 tons to 100 tons. Maintenance of a furnace, working in the manner described, is barely appreciable, seeing that with a six months' campaign at Livet the above furnace did not require any repairs either to linings, shell, or any other part. The lining only needed some attention when the furnace was put out of action owing to the water power supply failing.

The author feels it unnecessary too minutely to emphasise the advantages arising from the profound difference that exists between obtaining casting metal by the slow carburisation of previously-melted metal by

* As the result of the publicity given to the synthetic cast-iron process by the Livet Company after the first industrial working of the process in 1914 and in the beginning of 1915, a period during which over 20,000 tons were delivered, a number of small undertakings, struck by the underlying simplicity of the process, embarked in the recarburising melting of steel turnings, in any kind of furnace and wholly oblivious of the essential conditions. A number of synthetic pigs were thus placed on the market. The author was therefore able to study closely a number of them, displaying a very wide variation in carbon and silicon, which afforded opportunity for a number of adverse criticisms, which may be found reproduced in certain Italian technical journals (*La Metallurgia Italiana*, 1917, page 553, *et seq.*). It should be pointed out that these undertakings abounded more especially in Italy, there being a perfect "furore" to realise the large profits accruing from the production of cast-iron in a country lacking coal and inadequately supplied with iron. This situation became so marked that the Italian Government took alarm at the danger which foundries might incur from using these particular irons, and intervened. In order to put this intervention on a sound footing the Italian Minister of Munitions sent a committee consisting of an officer and a professor of metallurgy to the Livet works, to whom the fullest particulars were confided. The author was subsequently authorised to point out that the criticisms referred to applied only to the undertakings described, and to adduce the satisfactory testimony in favour of the process employed at the Livet works, as supported by the following metallurgical concerns, who indeed ordered the amounts standing in the second column, after their names:—

	Tons.
Compagnie Nationale des Radiateurs	12,000
Société des Affreteurs Réunis ...	15,000
Société des Hauts Fourneaux de Brousseval	10,000
Sclave Frères	10,000
Etablissements Magnard	10,000
Société Alsacienne des Constructions Mecaniques	5,000
Ant. Coste Caumartin	4,000
Acieries du Rhône	3,000
Capitain Geny	2,500
G. Martin	2,500

all of whom testify to the quality of synthetic cast-iron when made by rational processes.

* Paper read before the Iron and Steel Institute, on Friday, September 19, 1919.

* French patent Ch. A. Keller, No. 405277 of November 10, 1908, and certified addition No. 19358 to patent of September 11, 1913, and English patent No. 22692 of October 8, 1913.

contact between carbon and the bath (solution of carbon in liquid steel), and obtaining casting metal by the method described, based more especially on contact, at a high temperature, between solid or pasty metal and solid carbon. They are determining factors both from the standpoint of economics and of metallurgy. The fundamental economic considerations in the manufacture of synthetic pig-iron are as follows :—

1. The electrode consumption can be lowered to as little as 6 kg. per ton, with electrodes of good quality.

2. The consumption of unoxidised turnings is 1,050 kg. per ton of iron, a figure which, even with moderately rusty scrap, becomes only a little over 1,000 kg.

3. The amount of coke with 80 per cent. fixed carbon required to produce a ton of strong pig-iron with 3 per cent. of carbon and 1·75 per cent. of silicon, starting with normal turnings of shell steel, is about 80 kg.

4. A furnace of the 80-ton to 100-ton type should be provided with mechanical appliances for upkeep and charging, so that its operation does not require more than 15 workmen, for the preparation, by hand, of the charge, for charging, and for regulating the furnace.

5. Tapping, and loading up on trucks as required, needs seven men per unit, and handling in the stockyard another two men.

The general economy of the process, combined with the simplicity of the method of carrying it out, leads the author to believe that while synthetic iron found a very wide field of application during the war, owing to the very large production of steel turnings derived more particularly from shell manufacture, it will find no less a field after the war in, for example, producing those steel-like qualities of material required for highly-resistant mechanical parts.

The most obvious plan to adopt is to lay down a foundry for such parts adjacent to the synthetic cast-iron plant, as has been done at Livet. In such a case the foundry iron from the primary furnace may, if preferred, be made use of by transferring it to an electric mixer which can mix several casts and thus keep any quantity of metal ready for castings. This mixer, of the steel furnace type, allows of the quality being ascertained by samples being taken before tasting. It is needless to dwell at any further length on the method in question.

The manufacture of malleable cast-iron is likewise easily accomplished in the electric furnace, as the general quality of the steel turnings enables the low percentage of silicon and manganese required to be readily obtained, the reduced percentage of carbon present being dependent on the composition of the charge. It will also be seen that synthetic cast-iron may find a further field of application in the manufacture of special pig-iron, by means of special additions, such, for example, as nickel, chromium, &c. In such cases benefit will be derived, in making this kind of iron, from the absence of hydrogen, nitrogen, carbonic oxides and occluded air.

So much, therefore, for the cast-iron obtained under desulphurising conditions.

The materials required for national defence were generally confined to cast-irons whose purity, in regard to phosphorus, corresponded practically with that of the steels used in the production of synthetic cast-iron, seeing the sources whence these steels were derived. After the war the situation will be altered. Steel turnings will come from a variety of sources, and will no longer be under the same guarantees, so that very often it will be their dephosphorisation which will be of chief importance when a cast-iron of high quality is required.

The metallurgical value of the results obtained by the process alter completely when it becomes a question of dephosphorisation, which the author has practically accomplished by means of a dual process.

In the first place the steel turnings are melted in the presence of a small quantity of carbon and of a basic oxidising slag. It is necessary to aim at a critical carburisation which must be as high as possible, in order to lower the temperature of working and to facilitate the casting of the metal, while at the same time effecting dephosphorisation. A percentage of 1 or slightly over realises this object.

This first-stage dephosphorised metal, containing low percentages of silicon and manganese, is, according to circumstances, either cast into small ingots which are subsequently melted in an open furnace, mixed with the necessary additions of carbon and a desulphurising slag composed of materials containing exceedingly little phosphorus, or else poured into a second furnace of the bricked-in type, and covered with a layer of anthracite for recarburising. The synthetic cast-iron produced is controlled in respect of its silicon and manganese percentages by the addition of oxides and of a corresponding amount of reducing carbon, in the ordinary way. This mode of working somewhat increases the cost of production during the first phase, and further necessitates, in the second phase, a converting-cost equivalent to that of manufacturing ordinary synthetic cast-iron. About 1,500 kw.-hours must be allowed for the two operations.

The higher costs of manufacture are balanced by the higher value conferred on the synthetic cast-iron by reason of its extreme purity in regard to phosphorus, and likewise its purity from sulphur and its uniform composition in respect of silicon and manganese. From the commercial point of view such material can compete with Swedish iron.

The author will conclude this account of the chief metallurgical results obtained with synthetic cast-iron by describing an alternative process* which he has been led to contemplate in connection with the manufacture of steel from steel turnings.

As in the preceding example, the steel turnings are melted in an open furnace fed by the charge, but the slag, instead of being oxidising, is desulphurising, and the quantity of carbon introduced with the charge should be sufficient to reduce the oxides in the turnings and to carburise the metal to an extent distinctly above the percentage of carbon sought in the steel, so as to facilitate the pouring of the desulphurised metal and to allow of an oxidising working in the second stage of the operation.

For example, if a steel with 0·5 per cent. of carbon be required, the metal in the primary furnace may be poured at 1·5 per cent. of carbon. It will, as has been said, have been freed from sulphur during melting.

The secondary operation, which can be either in an open-hearth furnace or in an electric furnace, refines the metal and brings it to the required carburisation, while at the same time dephosphorising it. It then remains to bring the metal to the proper carbon content in the ordinary way by final additions.

This concludes the first portion of the paper, and the author believes that readers will share his conviction that the method of obtaining electrical iron by the synthetic process is destined to continue to play a useful part in metallurgy which will, as time goes on, be requiring a more and more high quality metal.

The production of synthetic cast-iron during the war has been considerable. It is not possible for the author to estimate at the moment how much has been produced at works other than those administered by the Keller Leleux Company at its works at Livet, Nanterre and Limoges. The production of these three works alone exceeded 150,000 tons, while it should further be pointed out that Nanterre has been devoted to other manufactures within the last eight months. It goes without saying that such an output could not be obtained solely from existing plants, but required a special industrial effort for the creation of new plants. These new plants are the subject of the second portion of this paper.

Part II.—The Process.

On June 20, 1914, the author read at the Livet works a paper before the Sixth International Congress of Chambers of Commerce on the subject of this process of manufacturing synthetic cast-iron, and giving the results he had accomplished since 1908, including more particularly an investigation of high tensile semi-steel obtained directly by the carburisation of steel turnings of the electric furnace. At this period a scheme for a works for the manufacture of malleable iron was about to be carried out. This was, however, interrupted by the war. Directly after the specifications for projectiles of semi-steel appeared, the author took steps to produce a metal coupling with the conditions laid down by the French Ordnance Department. By November, 1914, such an iron had been produced and investigated, corresponding with the following composition :—

	Per Cent.
Carbon	2·9
Silicon	1·75
Manganese	0·50
Sulphur	traces
Phosphorus	0·05

The test results obtained were as follows :—

Tensile strength, 50 kg. per square millimetre ; impact resistance, 60 blows (equivalent to fall of a 12-kg. tup from a distance of 89 cm. on a test-piece measuring 40 mm. by 40 mm., resting on two knife-edges 16 cm. apart, the distance of fall increasing 1 cm. at a time until rupture occurs), whereas the ordnance requirements only specify a minimum of 25 kg. per square millimetre for the tensile strength and 18 blows (equivalent to 44 cm.).

The first electric furnace, of 20 tons, was started in 1914. The uniformity of the iron and the tensile qualities obtained led to its being immediately considered from the standpoint of shell manufacture. The Ordnance Inspection Department, after due examination, showed itself favourable, and before the end of 1914 the first series of 220-mm. shells of semi-steel yielded excellent results at the Bourges proof range.

Orders from the department were the immediate result of these favourable trials. The manufacture of 220-mm. shells of synthetic semi-steel was thus undertaken at Livet on a commercial scale from the commencement of 1915. A complete foundry was erected and furnished with electrical furnaces for the refining of the iron, and the production, which was in the first instance at the rate of 50 shells per day, was raised in 1916 to 300 220-mm. shells, together with 10 high-explosive 400-mm. shells requiring 55,000 kg. of raw metal.

In order to comply with the best practical conditions for running the foundry, the iron obtained in three primary furnaces is run into a ladle of 5 tons and poured into three 7-ton electric mixer furnaces, each taking 400 kw., to reheat the metal if necessary, and in any case to keep it hot during the period that iron is being used, and to check the quality. Despite the very uniform composition of the primary furnaces a carbon test, which only takes 20 minutes, is carried out by the foundry staff before pouring, in addition to ascertaining the quality by a quench test which serves more particularly to check the silicon.

The mixer-container furnaces for steel are of the Ch. A. Keller type, that is to say they have a roof and doors. The electric current enters by a vertical electrode, and leaves through the conducting hearth, of the reinforced puddle type (vertical bars plunged into tamped magnesite). A conducting hearth of this description is practically unwearable, being non-susceptible to any cracking. If the bottom conducting surface of the hearth wears gradually lower, repairs are very easily effected by spreading over the bottom, while still hot, a special conducting puddle consisting of magnesite and fragments of iron mixed in tar. All holes are thus easily filled up without either the framework or the working of the hearth being interfered with in any way. From a metallurgical point of view this method of repairs corresponds in principle with that employed for the hearths of open-hearth furnaces. The furnaces are, of course, of the tilting type which allows of any quantity of metal, no matter how small, being drawn off. (*Fig.* 1.)

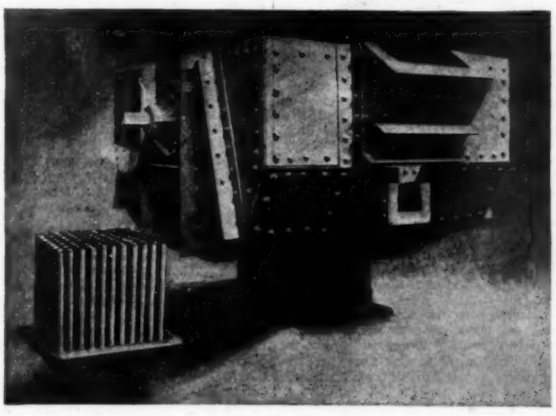


Fig. 1.

Tilting type of Keller Electric Furnace with conducting hearth.

The liquid iron poured in is covered with basic slag, which forms a protecting layer, preventing oxidation and breaking the electric arc. When pouring is to be done, this layer is easily retained by a little brickwork or sand pocket at the entrance of the furnace spout. Practice has shown the advisability of interposing these mixer furnaces, which keep the metal so that it can be checked from time to time by the technical staff, who thus acquire a high degree of skill, seeing the ease with which the metal can be held waiting. Generally speaking, it may be said that the metal remains an hour in the mixer furnace, including the time of pouring, for the filling up of these furnaces is carefully adjusted to correspond with casting operations in the foundry. The metallurgical adjustments are very easily carried out, as any additions, as well as the withdrawal of the test samples, are effected through the working door. The practice described gives complete satisfaction ; in particular it invariably ensures uniform metallurgical results, thus eliminating all rejections due to insufficient tensile strength.

The upkeep of the mixer furnaces is but trifling. The interior lining of the mixer lasts a couple of months, and the roof over three months. The electrode consumption is on an average 2 kg. per ton of iron ; the average power consumption is from 50 kw. to 100 kw.-hours per ton, according to the conditions prevailing in the foundry. A single workman is required for the working of the furnaces, and he also looks after the tapping, the electrical manipulation of the tilting arrangements, and the taking of samples.

The machining of the shells, which was originally placed out with subcontractors, was carried out at the Livet works towards the end of 1916 under ordnance inspection, and thus, without the intervention of any transport or the use of any coal except for the chemical composition, the manufacture of semi-steel shells from steel turnings was wholly carried out in one works. This concentration of plant reduced the number of rejections to a very small amount, not exceeding, when

* French patent, Ch. A. Keller, No. 81928 of December 29, 1915.

the necessary skill had been attained, 7 per cent. on the cast shells inspected.

The capacity of the electrical foundry at Livet could not keep pace with the output of casting metal, which began at 20 tons per day, was subsequently increased to 60 tons, and later on reached not less than 300 tons during the period of maximum water-power supply. Several outside works manufacturing shell were supplied with the surplus output. These firms all testify to the uniformity and excellent quality of the iron supplied. The quality of the iron supplied to outside firms corresponds with the following composition, which complies with the best metallurgical practice: Carbon about 2·75 per cent. and silicon about 2 per cent.; so that, after a cupola melting, the artillery specifications could almost be met without any addition of steel, as both recarburisation and reduction of silicon accompany fusion in this type of furnace. Each wagon load sent out was accompanied by an analytical report showing what additions of steel and of ferro-silicon might be needed. Very often no such additions were required.

This method of working usually conduced to obtaining good metallurgical results in shell foundries. The care with which the analyses were made was carried to such a point that qualities specially standardised for carbon and silicon were supplied to smelters in order to check abnormalities due to remelting in certain cupolas.

Even the enlargement of the existing Livet works has now become insufficient to deal with such a development.

Part III.—New Works at Livet and Elsewhere.

A new special works was laid down in November, 1915, some hundreds of yards from the original works, with which they were connected by railway. The new works were started on July 12, 1916, first with a furnace of 80 tons to 100 tons, and were subsequently enlarged. The building occupied an area of 12,500 sq. m., and comprised more particularly four parallel shops. The first shop, which was 300 m. in length, and alongside the railway, served for unloading the raw materials and more especially the steel turnings, which are handled by means of a powerful electromagnet suspended from a high-speed crane. The turnings are either used at once in the cycle of operations, or put into stock in a deep trench occupying a portion of the length of the shop, from which they are withdrawn by the same means. By this arrangement a 12-ton wagon can be unloaded in 20 minutes.

The second shop, which was situated between the unloading shop and the electric furnace shop, served for the preparation of the charges, which are mechanically raised by large bucket elevators to the furnace platform, where they are tipped on to the latter by small wagon loads at a time and heaped around the electrodes.

The transformers are housed in sheds built on reinforced concrete foundations on the level of the platform of the electric furnaces. This arrangement possesses the advantage of leaving the second shop entirely free, and also reduces secondary distribution to a minimum. Each shed contains the transformer panel-board which is connected with the central supply by means of an armoured cable, leading to a long upper gallery of reinforced concrete, in which are housed the buss-bars and all the switches (registering meters and watt meters). This gallery, which is just beneath the roof, is capacious enough to allow of easy access, while its position isolates it as completely as possible from dust, and prevents any danger arising to the staff.

The third shop contains five Ch. A. Keller furnaces of the "electrodes in series" type arranged in line, four being of 2,000 kw. and one being of 2,500 kw. The output capacity of this installation is 300 tons of synthetic iron per day. This output could not be maintained, particularly in 1918, owing to various circumstances which were, however, quite independent of the plant itself.

Loading the iron on to wagons is effected by means of an electromagnet suspended from an overhead electric crane, which serves a line of railway parallel with the front of the electric furnaces. By this means a 10-ton wagon can be loaded up in 15 minutes.

The lay-out of these works provides for a complete unit of manufacture, in transverse section, for each pair of furnaces, this arrangement being repeated along the whole length, and thus securing the best possible arrangement for the supply of raw materials, and for the removal of the manufactured products, each unit having lines of railway along its sides and being thus connected up with both ends of the works. The haulage of the wagons is effected by electrical capstans placed throughout the plant. At one end of the works a shop at right angles to the shops just described has been laid down to house electrical converter furnaces to serve a steel foundry. The special synthetic iron employed for this conversion is poured into a ladle on the side of the furnace furthest away from the pig-iron beds. The ladle can thus be conveyed along a longitudinal pit by an electric overhead crane, so that its contents can be poured into the converting furnaces. This arrangement for casting from both the opposite sides of the electric furnace enables the material to be cast, very conveniently, either into pigs or poured into the ladles.

At the end of the plant are two large shops intended ultimately to serve as rolling-mills and to house the accessory appliances.

Part IV.—The Development of New Waterfalls.

The rapid extension of the use of synthetic cast-iron led the Keller Leleux Company not only to lay down new works for its manufacture, but also to develop fresh waterfall supplies in order to increase the power resources at the Livet works.

1. *The Vernes Fall* (7,000 h.p.).—For this reason in August, 1917, work was undertaken in connection with the Vernes Waterfall on the Romanche. The new hydro-electric works was put into operation in July, 1918, and therefore was approximately in time to subserve the requirements of the war. The nominal power is 7,000 h.p., the height of fall being 20½ m. The hydraulic works comprise a subterranean canal, 208 m. in length, under the Livet works, a tunnel of 15 sq. m. and 620 m. in length in the mountain, and a reinforced concrete conduit 3·6 m. in diameter and 132 m. long, ending in a reinforced concrete water chamber with special arrangements for the evacuation of the reflux waters. Two steel conduits of 2·5 m. in diameter feed the 3,500 h.p. turbines of the power-house.

This waterfall, which makes use of the water of the Romanche actually at the point of outflow of the Livet Works, required, therefore, neither a dam nor a settling pond. The additional power thus developed at the Livet works corresponds with an increase in the output of synthetic cast-iron equal to 25,000 tons per annum.

2. *The Bâton Fall* (7,000 h.p.).—Despite considerable difficulties in connection with the harnessing of this fall, which is 1,100 m. high, the Keller Leleux Company undertook operations towards the close of 1917, with the object of extending its share in the national defence by increasing its output. It is anticipated that operations will be completed during the current year, although it still remains to complete the tunnel of 1,050 m. in length and situated at an altitude of 1,900 m., by which the water is led to the works, and for the carrying out of which a winter station was established in 1917. It will also be necessary to complete a conduit (of a total weight of 400 tons) which will have to be clamped to the steep mountain side for a length of 1,600 m. The hydro-electrical machinery is on the point of delivery.

If the utilisation of the Vernes Fall may be regarded as one of the feats of the war, it is to be hoped that by a future triumph the Bâton Falls may be reclaimed for the purposes of the peace.

Part V.—New Electro-Metallurgical Works.

National Gun Foundry of Nanterre.—At the end of 1916, Mr. Albert Thomas, Under-Secretary of State for Ordnance, and Mr. Claveille, Director of Gun Manufacture, commissioned the author at the expense of the State to lay down and equip the works at Nanterre for an output of 300 tons of synthetic cast-iron per day, employing power derived from the sector of the "Société d'Energie Electrique de la Region Parisienne," whose power-house had just been completed.

The electro-metallurgical works, which is known as the National Gun Foundry of Nanterre (Fonderie Nationale d'Artillerie de Nanterre), comprises seven furnaces, of which six are in operation, requiring 10,000 kw. It was built in 182 effective working days, with the wonderfully active and energetic help of the "Société Générale d'Entreprises" for all contract work. It was put into operation on July 3, 1917. The works, which was designed for the manufacture of synthetic steely-iron for shell manufacture, at once realised its industrial purpose. The anticipated results were, indeed, surpassed, and the quality of the iron was very greatly appreciated by ironfounders on account of its uniformity and purity.

The consumption of materials per ton of pig-iron for the 1,650 kw. type of furnace employed was as follows:—

	Kilogrammes.
Steel turnings	... 1,133·00
Coke	... 89·95
Electrodes	... 6·1
Kilowatt-hours	... 815·00

The electro-metallurgical works, which was connected to the Havre Railway, comprised an important network of sidings intended to accommodate trains of 40 wagons at a time. The area occupied is 15,000 sq. m. The works itself is composed of three sets of buildings, of which the largest consists of three parallel shops each of the same length, and the arrangement is practically the same as at Livet, which has already been described. At Nanterre, however, the electric furnace shops and the wagon-unloading shops are combined and furnished with an overhead crane of wide-span, which further accelerates working. The handling arrangements have been divided into two sections of 150 tons per day, each furnished with an overhead electric crane, for unloading raw materials, with an electromagnet for the turnings and a bucket grab for the other materials, while in the furnace shop there is an overhead crane for loading the pigs on to trucks. The stocks of steel turnings for current use are stored at the two ends of the third shop and are carried to the charge-mixing shop and dropped from the electromagnets into intermediate hoppers made of ferro-concrete. The various materials, such as coke and the slag constituents, are stored in the centre portion of the raw materials shop. They are crushed, after unloading from the wagons, and hoisted in large reinforced concrete bucket hoppers, from whence they are delivered through holes in the bottoms to the trucks. The coke employed for carburisation goes from the crusher to a rotary fan drier, which reduces the moisture to less than 1 per cent. Two bins are always in use for holding the coke, one full for current manufacturing purposes and the other in process of being alternately filled. This system allows of the amount of fixed carbon, as coke, which is in course of consumption, being accurately known. The charge-mixing shop is adjacent to the raw material storage sheds, and comprises a longitudinal pit in which run the service trucks. These are raised by electric hoists to the electric furnace platform, each hoist serving two furnaces.

The electric furnaces are charged by the wagons being tipped on to cast-iron travelling bands, which take the material to the electrodes. The furnaces are built in line at a distance of 30 m. apart from centre to centre. The transformers are housed in sheds on the level of the charging platform. The distributing system for the three-phase 5,000-volts electric current consists of armoured cables carried in a subterranean chamber alongside the longitudinal pit in which the wagons run, so that the manholes give on to the side of the pit. Connection with incoming current and with the power station is by means of seven armoured cables of 800 sq. mm. in section, of which one serves as a relay.

The electric furnaces are controlled from a control station situated between each pair and is effected by hand, the variations being slight. The arrangements for lowering and raising the electrodes are likewise mechanical. The electric furnaces are of the Ch. A. Keller monophase type, with the electrodes in series.

After water sprinkling, the stripping of the pigs, still attached to the runners, is carried out by means of an overhead crane and a 2,000-kg. electromagnet. The entire sow and pigs are raised and dropped in the space between the furnaces, the impact breaking them into separate pieces; the electro-magnet then lifts them and loads them on to wagons running along the front of the furnaces. A single workman can easily strip the bed, break up and load up the 150 tons produced daily by each group of three furnaces.

The manufacturing plant proper ends with a shop where the electrodes are prepared, agglomerated in sets of four, the individual rods being connected with the lead-in piece by a fused joint. The blocks so formed are taken by an electric hoist to the smelting shop, and discharged on the end of the electric furnace platform, from whence they run on rails to the different furnaces.

Another set of buildings contains the accessory plant, filling shops, the transformer house for turning three-phase current into continuous current, the pumps for supplying the works with water, stores and foremen's offices, &c. The plant contains a very capacious stock pit for turnings, 150 m. long and served by an overhead electric crane carrying an electromagnet, the wagons running beneath the crane. This store shed can hold 50,000 tons of steel turnings. The railway alongside of it is connected with the main lines of the works and with a wharf on the Seine, furnished with an electric crane similarly equipped with an electro-magnet to unload the barges containing the steel turnings, which are collected from works in the vicinity. It also serves to load up the output. The finished iron to be placed in the stockyard is loaded up on wagons by means of a crane running along the front of the melting shop. All these arrangements have given excellent results, and have reduced handling to a minimum. There are also well-fitted laboratories and a medical service connected with the works.

Labour.—Labour was supplied by prisoners of war and by mobilised workmen, who are boarded and lodged by the works, which has put up for this purpose a number of huts, dormitories, and canteens.

In order to provide for future urgent needs the power supply of the electro-metallurgical works at Nanterre has been increased to 15,000 kw., to be used in the nine monophase 1,560-kw. furnaces housed in a melting shop, 175 m. in length.

The Limoges Works.—Simultaneously with the undertakings created at Livet, the Keller Leleux Company, in co-operation with the Société Générale d'Entreprises, established a works for the manufacture of synthetic cast-iron, the power supply being the surplus energy developed at the Eymoutiers Hydro-Electric works, belonging to the Departmental Railway Company of Haute-Vienne.

The electric furnace, which is one of a 1,000 kw., was worked in 1916 in parallel with the tramway system, practice having shown that this arrangement is advantageous.

Villefranche Works.—A similar plant, the power capacity of which is 2,000 kw., has been laid down by the Keller Leleux Company at Villefranche, to use the surplus power developed by the Midi Company on its line from Perpignan to Bourg-Madame. This works has only just been completed.

It is incontestable that the war has stimulated extremely rapid development of the manufacture of synthetic cast-iron owing to the abundance of steel turnings and the practical difficulties of using them before 1916, with the result that a considerable quantity of French steel turnings used to be exported, chiefly to Italy and Spain. Since that time blast-furnaces have become large consumers, and the problem of what is their best mode of utilisation—either in the blast furnace or in the electric furnace—now deserves further investigation. Questions of transport now play so considerable a part, that in this as in all other cases it is necessary carefully to determine from time to time which is, nationally, the most economic method of using them. Whichever way the question may be decided there is no doubt that a recarburising fusion by electric power derived from waterfalls constitutes the most economical mode of utilising such turnings, in so far as it involves a complete economy of coal. It is therefore towards electrical furnaces supplied by water power that we must look for the utilisation of steel turnings, although the post-war conditions may modify the existing situation. The possibilities connected with the manufacture of synthetic dephosphorised iron must depend in the first place on the supply of steel turnings, but ultimately on the difference between the cost of coal and the cost of developing water power. The whole of the conditions will have to be reviewed later, when war conditions have yielded to conditions of normal equilibrium, but respecting which, for the moment, all forecasts are at present speculative. It will be seen none the less that synthetic cast-iron has filled a useful gap in the production of pure iron and has rendered valuable help to the cause of National Defence.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

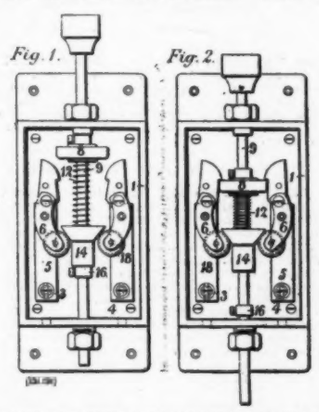
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

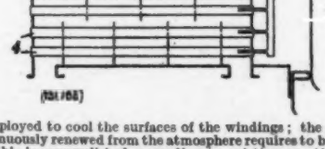
ELECTRICAL APPARATUS.

131,191. A. J. Bonnella, London, and R. K. Damey, London. Electrical Switch. (4 *Figs.*) September 16, 1918.—This invention comprises an electric fly switch in which the moving contact member of the switch is held in closed position by a locking device, while a spring acting upon both the moving contact member and the locking device tends to force the former into its open position, and the latter into its locking position. The switch is built in a box 1, the contact parts being mounted on a sheet of fibre. 3 and 4 are the terminal screws of the switch fastened upon metal blocks 5. Upon each block 5 is pivoted a hooked member 6, the hook of which is adapted to engage over the end of a movable contact bridge 8. This bridge is free to slide upon a metal rod 9, from which it is insulated, but its motion upon the rod is limited on the one hand by an adjustable collar, from which it is separated by a disc of fibre, and on the other hand by a spring 12 from which it is separated by a fibre washer. The spring at its other end bears upon an insulating sleeve 14 formed with a coned end. This sleeve is also free to ride on the rod 9 within the limits imposed by the spring 12 and another adjustable collar. The rod 9 projects through stuffing boxes in the box 1, and carries an insulating handle. The coned part of the sleeve 14 bears upon and presses outwards the rollers 18 carried in the end of the hooked members 6. If when the parts



are in the position shown in Fig. 1 the handle is pressed down, the bridge-piece 8 is carried down. The cone of the sleeve 14 immediately bears upon rollers 18 and presses them outward as far as they will go. This brings the hooks into the path of the bridge 8. But when this reaches the hooks it will force them apart, their ends being bevelled for that purpose, and in so doing will rock the members 6 and cause the rollers 18 to move the cone up and slightly further compress the spring 12. Finally, the hooks will spring over the edges of the bridge 8 and prevent its return. The parts are then in the position shown in Fig. 2. The bridge-piece tends to rock the hooks outwardly, but is unable so to do because any small initial longitudinal movement of the bridge would, by rocking the members 6, cause a greater longitudinal movement of the cone; in other words, would cause a further compression of the spring. The parts are therefore in stable equilibrium. But if the upper handle is pulled upward or the lower handle pressed upward the collar 16 will bear upon the sleeve 14 and will push it upward further compressing the spring 12. As the cone moves upward the rollers 18 can move inward, and therefore the hooks can move outward until the bridge 8 is released, when it will immediately fly back as the spring 12 extends, thus giving the usual quick break. (*Accepted August* 27, 1919.)

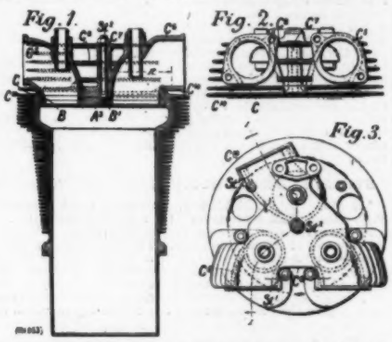
131,185. Lo-Thermo Patents, Limited, Manchester, B. Longbottom, Alderley Edge, and E. Greenhalgh, Rusholme, Manchester. Dynamo Electric Machinery. (3 *Figs.*) September 10, 1918.—In certain classes of dynamo-electric machinery, particularly in turbo-electric generating sets, it is not usually possible to dissipate, by radiation in the ordinary way, the heat which is generated as a result of the various losses, and atmospheric air, driven by a fan through the machine casing,



is employed to cool the surfaces of the windings; the air being continuously renewed from the atmosphere requires to be filtered, and this is accomplished, according to existing practice, either by wet-spray filters or by dry filters. The necessity for filtering is avoided by enclosing the air which circulates through the machine casing so that it circulates in succession through the said casing and through a heat exchanger. According to the present invention, on the one side the heat transmitting surfaces of the heat exchanger are wetted with water delivered in the form of fine spray from a series of nozzles, and air is circulated over the said surfaces so that they are cooled not only by the air but also by the evaporation of the water. The heat exchanger 1 is preferably tubular, the circulating air to be cooled being led from the machine outlet to the heat exchanger casing and being caused to flow in a circuitous path round the outsides of the tubes 4 and then back to the machine casing, its circulation being effected by means of a fan or fans mounted on the machine rotor within the machine casing, or by means of an independent fan, or by both means combined. A separate current of cooling air, which does not mix with the enclosed air, is driven through the tubes 4, and water under pressure is conveyed to a series of nozzles or sprayers 10 adapted to wet the interior of the tubes, and the air currents through the tubes are of such velocity as to effect, in conjunction with the heat transmitted through the tubular surfaces, the evaporation of the water and to dissipate the heat so transmitted. (*Accepted August* 27, 1919.)

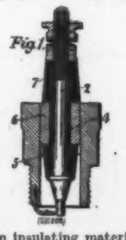
GAS ENGINES, PRODUCERS, HOLDERS, &c.

131,053. A. H. R. Fedden, Fishponds, Bristol, and Brazil, Straker and Co., Limited, Fishponds, Bristol. Internal-Combustion Engines. (4 *Figs.*) April 5, 1918.—This invention relates particularly to the cylinders of air-cooled internal-combustion engines of the known type, having a barrel with an integral head at or near one end, and a cap secured in close contact with the head for the purpose of conveying the heat therefrom and dissipating it. In known constructions, the cap is located on the head by one or more projections on one of the opposed faces spigotting into the other face, or by upstanding flanges on the integral head engaging the cap. In an internal-combustion engine according to this invention, a cylinder has the highest portion of its head A^3 formed integral with it as a flat plate devoid of upstanding projections and combined with a cap C, which is stiffened against buckling by hoods such as



C^5, C^6, and a pillar or pillars C^7 that are integral with it and are tied together by parallel radiation fins C^8, and which is maintained as to its under face in contact with the upper face of the head, not only by means a^2, which hold the centres of the two flat faces together, but also by studs a^3 disposed around the centres within the radius of the cap, with or without a circumferential corrugation (such as C10) around the head. The location of the cap on the head is effected by one or more separate dowel members B, B^1, engaging recesses in flat contacting faces, whereby the two faces may each be formed without any projection or protuberance thereon. The dowel members B, B^1, which are made of a material of higher thermal conductivity than that of the parts in which they are inserted, and are preferably disposed at such points on the integral head of the cylinder as require special cooling, consist, for example, of copper rings disposed one around each exhaust port. (*Accepted August* 27, 1919.)

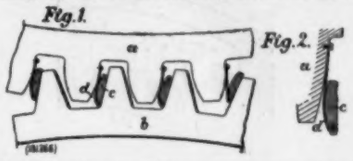
131,268. J. E. Barrows, Moseley, Birmingham. Sparking Plugs. (4 *Figs.*) August 1, 1918.—This invention refers to that class of sparking plug in which the central electrode with its insulation is assembled as a separate inner unit externally tapered and adapted to fit into the casing in such manner that the pressure of the engine explosions tends to force this unit into the casing, the degree of taper being such as to hold the two parts together entirely by friction. According to one part of the invention, a sparking plug of the kind referred to comprises an



electrode 2 enclosed in insulating material 4, additional upper and lower non-conducing members 5, 7, disposed around said insulating material, and a metal sleeve 6 clamped between said upper and lower non conducting members, said metal sleeve having a tapered exterior surface. The exterior surface of the metal sleeve 6 may be ground. According to a further part of the invention, the inner unit of the plug instead of being mounted directly in the plug casing may be carried by a sleeve, which is adapted to screw into or on to a plug casing. (*Accepted August* 27, 1919.)

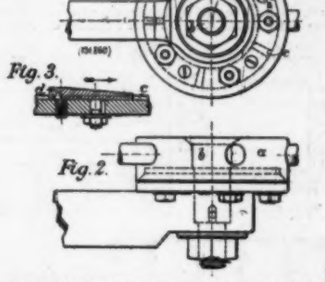
MACHINE AND OTHER TOOLS, SHAFTING, &c.

131,266. Aktiengesellschaft Brown, Boveri and Cie., Baden, Switzerland. Toothed Wheel Gearing. (3 *Figs.*) October 17, 1918.—According to this invention, there is interposed between intermeshing teeth movable intermediate members that are adapted to roll over the teeth flanks of one wheel in the plane of the said wheel, whilst they slide along the teeth flanks of the other wheel. *a* is assumed to be the driving toothed wheel, and *b* the driven toothed wheel. *c* are the intermediate members which, as shown in Fig. 2, are attached to the wheel *a* by means of flexible leaf springs *d*. The said intermediate members enter between the teeth flanks of the two wheels at the intermeshing point, and move in such a manner that they slide along the teeth flanks of the wheel *b*, whilst they roll over the teeth flanks of the wheel *a*. Moreover, the eccentric situation of the sliding members is apparent from Figs. 1 and 2. As shown, the point of pressure contact of the sliding member is correctly eccentric from the beginning of the meshing up to the point of contact between the pitch circles. The point of pressure contact is central at the point of contact of the pitch circles, in which position there is no sliding motion. In the continued motion of the toothed



wheels the direction of the sliding motion changes and the position of the point of pressure contact also changes, thus bringing the point of pressure contact back again in to an eccentric position so as to facilitate the formation of a wedge of oil between the surfaces. (*Accepted August* 27, 1919.)

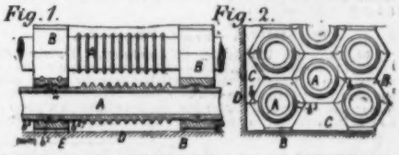
131,260. P. Eichenberger, Courfaivre, Switzerland. Lathes. (3 *Figs.*) May 16, 1919.—The present invention relates to a revoluble tool-box for use in the slide rest of the lathe. According to the present invention, a ratchet wheel, by means of which the tools are fixed in the various working positions, is provided with teeth which are fitted to the wheel in such a manner that their angular positions can be slightly adjusted with respect to one another. *a* is the revoluble tool-box. It is provided with holes for the reception of the various tools, and rotates about a bearing *b* by which it is maintained in close contact with a



ratchet wheel which engages a pawl and so secures the tool-box in the various working positions. The ratchet wheel is fixed to the tool-box support, and the latter is fixed to the slide rest of the lathe. The side of the ratchet wheel which faces the tool-box is provided with a groove *e* (Figs. 1 and 3) concentric with the axis of rotation of the moving parts, in which are fitted five teeth *d*, which are held in position in the groove by means of bolts, of which the shanks pass through elongated slots through the ratchet wheel into the groove, and thus allow the position of the teeth with respect to one another to be varied. (*Accepted August* 27, 1919.)

MINING, METALLURGY, AND METAL WORKING.

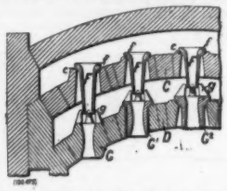
130,471. Smeeton-Wright Furnaces, Limited, Westminster, London, J. E. Fletcher, Westminster, London, and T. Wright, Westminster, London. Recuperators for Furnaces. (9 *Figs.*) August 1, 1918.—This invention relates to recuperators for furnaces, of the type in which heat is interchanged between gases, one of which may be air, passing respectively through and around a set of recuperator tubes. According to this invention, the recuperator tube A is formed with enlarged ends *a* preferably rounded, and is fitted in a flange B made in two parts and recessed to receive the tube enlargement or pair of adjacent tube enlargements and to form a joint by the aid of cement or jointing material. The divided flange B forms part of the wall of the built-up recuperator, the flanges making joint with each other so as to make a complete gastight wall at the ends



of the recuperator. The two halves of each divided flanges are preferably rebated at *b* from face to face so as to form a stepped joint to take any thrust which may be developed in the wall without transmitting it to the tubes. To complete the wall and fill up the spaces around the edges, special spacing bricks C are employed which are placed in position against the sides, top and bottom of the outer walls D of the recuperator structure, between the edge flanges. The divided flanges B unite the adjacent ends of the tube elements by the aid of recesses b^2 which receive the rounded enlarged ends *a* of the tubes and leave sufficient space for the cement E to form an efficient bond. To improve the joint the faces of the flanges B are preferably made with channels b^3 closely encircling the tubes A and also filled with the cement. (*Accepted August* 13, 1919.)

130,475. Smeeton-Wright Furnaces, Limited, Westminster, London, J. E. Fletcher, Westminster, London, and T. Wright, Westminster, London. (3 *Figs.*) August 1, 1918.—This invention relates to gas-fired furnaces for heating steel, iron or other materials of the type in which separate supplies of gas and air are introduced into the crown of the furnace and mix as they are directed downwardly into the furnace, and it relates more especially to the burners for use in such furnaces. According to this invention, instead of employing fixed perforated bricks or blocks as burners, as in the usual practice, separate burner nozzles F, are provided, more especially in the upper or intermediate arch or wall C of the crown, the said nozzles being supported in an angularly adjustable manner, to maintain good alignment in spite of relative expansion and contraction between the different arches or walls of the crown. In the preferred construction, the nozzles F are formed with flanges *f* having spherical surfaces resting in corresponding seating at the upper edges of apertures in the crown C. In the lower wall

or arch D of the crown through which gas and air mixture is projected into the furnace, fixed burner blocks G may be employed with suitably formed apertures, or separate mixture burner



nozzles G1, G2, may also be fitted, the upper nozzles being preferably guided at their lower end by lugs or guiding pieces g on the upper end of the lower nozzles or blocks. (*Accepted August* 13, 1919.)

131,263. D. J. Gascoigne, Coventry, and A. Smith, Coventry. Foundry Moulding Boxes. (6 *Figs.*) May 27, 1918.—This invention relates to foundry moulding boxes, its principal object being to provide by a casting process, boxes of such accurate shape and dimensions that no machine work is thereafter required upon them, so that time and labour are economised and production costs are reduced. The mould-box A has raised parts A^2 around the edges of its open ends where it joins a co-operating box. The faces of these parts lie in a plane that is parallel to the plane of those at the opposite end of the box, such faces being usually machined true in ordinary cast boxes. To produce these faces accurately in the casting process, the mould flask shown in Figs. 2, 3 and 4 is employed. This consists of upper and lower parts B, similar to one another, and an intermediate part B^2. The parts B have box-bars B^3 whose inner edges B^4 are machined so that their surfaces lie in a true plane, which preferably includes the jointing edges of the flask B. The three parts of the flask are aligned with one another by the usual means, and are held together by bolts situated at

Fig.1.

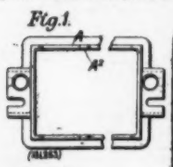


Fig.2.

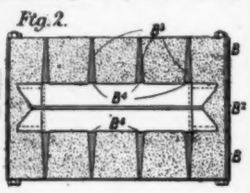


Fig.3.

Fig.4.

their four corners. By employing distance pieces, as for example sleeves with faced ends around the bolts and between the flask parts B (Figs. 3 and 4) the distance apart of the latter are accurately determined so that the respective faces B^4 of the bars B^3 which they carry are parallel to one another, and are also opposite one another as the parts B are alike. In moulding and casting the box A, the lower of the two parts B of the flask is rammed up with sand in the known manner, the intermediate flask part B^2 is located by known means, and the pattern placed, so as to rest with the faces corresponding to those indicated by A^2 in Fig. 1 on the faces B^4 of the bars B^3, as shown, and rammed up. The upper part B is then put in position and securely fixed by the bolts—the length of the sleeves upon which it bears being preferably such as to cause a slight pinching of the pattern between the faces B^4 of the bars. The upper part of the mould is then completed, and after removal of the pattern the metal is poured. It will thus be apparent that when removed from the mould the parts A^2 of the box A will have accurately-finished faces without the necessity for subsequent machining. (*Accepted August* 27, 1919.)

MOTOR ROAD VEHICLES.

130,498. G. Woodvine, Shrewsbury. Driving Gear. (2 *Figs.*) September 3, 1918.—This invention has for its object to improve the construction of driving gear for motor vehicles, the gear being of the type in which power is transmitted from the motor arranged parallel with the rear axle through a chain drive and differential gearing to the live back axle and road wheels of

Fig.1.

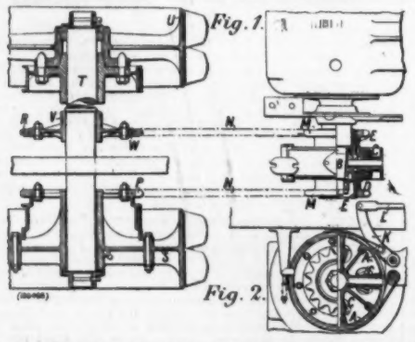
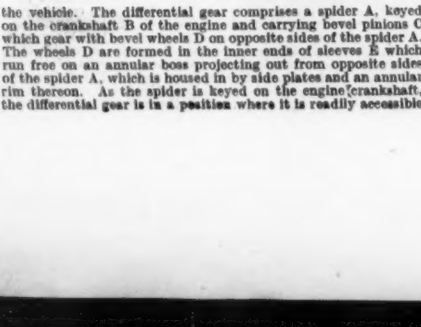
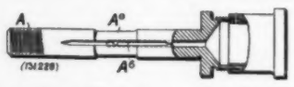


Fig.2.



the vehicle. The differential gear comprises a spider A, keyed on the crankshaft B of the engine and carrying bevel pinions C which gear with bevel wheels D on opposite sides of the spider A. The wheels D are formed in the inner ends of sleeves E which run free on an annular boss projecting out from opposite sides of the spider A, which is housed in by side plates and an annular rim thereon. As the spider is keyed on the engine crankshaft, the differential gear is in a position where it is readily accessible for renewal or repair, and where its weight is spring-supported instead of being a dead load on the back axle as usual. The annular rim acts as a drum on which a brake band bears, this band being operated from the driving platform of the engine by a lever K and a rod L. The outer end of each of the sleeves E carries a sprocket wheel M, from which the drive is transmitted by sprocket chains N to similar sprocket wheels P, R, one P of which is bolted to one of the road wheels S, which wheel runs free on a live back axle T, whilst the other sprocket wheel R is secured to the axle T on which the other road wheel U is fixed. The sprocket wheel R is made up of a solid central portion V having the toothed portion W, which is made in sections, bolted to it. The segments can thus be easily detached at any time without interfering with the axle itself. (*Accepted August* 13, 1919.)

131,228. The Streatham Engineering Company, Limited, Streatham Hill, London, and A. C. Cordell, West Ealing, London. Lubricating Shackle Pins. (3 *Figs.*) January 3, 1919.—This invention relates to shackle pins of the type usually provided with a reservoir for the supply of lubricant. Usually the lubricant, for example grease, is forced along an interior bore from the reservoir, and finds its way to the bearing surfaces, through one or more radial holes. These holes soon become choked with foreign matter, which it is the object of the present invention to avoid. Accordingly, the shackle pin A is provided with one or more reduced portions A1, to which lubricant is fed direct from the interior of the pin through holes, and from which



it is spread by spreading grooves A_6. Thus the reduced portion forms a channel, relatively shallow, around that part of the pin, which becomes filled with lubricant which is ultimately spread along the pin by the grooves. As the holes lie in the reduced parts they are prevented from becoming choked. In an alternative form, the reduced portion of the shackle pin has located loosely around it a split band or sleeve, covering the radially-disposed holes and spiral or other grooves cut in the surface of the reduced portion. On relative movement taking place between the bearing or the shackle and the pin, the band or sleeve is caused to creep round, and thus the grease is well and evenly distributed to the bearing portions. (*Accepted August* 27, 1919.)

STEAM ENGINES, BOILERS EVAPORATORS, &c.

130,486. J. G. Robinson, Fairfield, near Manchester. Pulverised Fuel Furnaces. (2 *Figs.*) August 16, 1918.—This invention relates to the employment of pulverised fuel in the furnaces of steam generators. The invention consists in the provision of a small steam engine a for driving the fuel screw conveyors 5 through a two-speed gear, while the fan or blower 9 for supplying the forced draught is normally driven by a turbine 7 or another engine as before, means however being provided according to the present invention, for enabling the small engine

Fig.1.

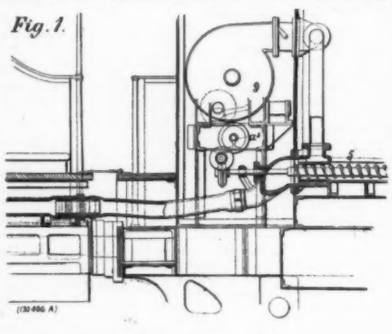
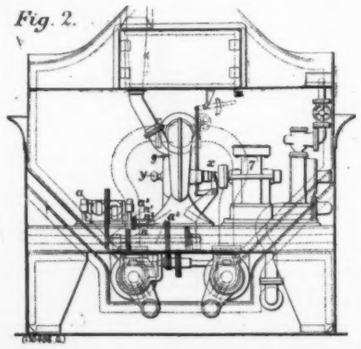


Fig.2.



to be also utilised for driving the fan or blower should the turbine or other engine not be available. In normal working, the turbine 7 (see Fig. 2) is used for driving the fan or blower 9, but in the event of the turbine breaking down the fan can be temporarily driven from the small engine a by uncoupling the turbine 7 from fan or blower 9 at the clutch x. The fan 9 can then be temporarily driven from the engine a through a countershaft a^3 and gear n, n^1, to a shaft n^2 and chain wheel and chain drive to a chain wheel y mounted on the end of the fan shaft remote from the turbine. (*Accepted August* 13, 1919.)

130,468. The Stirling Boiler Company, Limited, Westminster, London, and H. J. S. Mackay, Ryde, Isle of Wight. Water-Tube Boilers. (3 *Figs.*) July 31, 1918.—This invention relates to watertube boilers of the Stirling type. In accordance with the invention, the feed trough d for the supply of water to the boiler is so arranged in the rear drum b as to supply only a portion of the rear bank, say a central portion A1 approximately equal to one-half of the rear bank of tubes, and the lower or mud drum c is fitted with an imperforate diaphragm i dividing the whole of the rear bank from the front and intermediate banks of tubes l, k. The feed trough d is enclosed by transverse partitions e and longitudinal partition f so as to form a watertight compartment g from which the water from the feed trough can pass to the central portion of the rear bank of tubes h. The water supplied by the feed trough d to the central portion of the rear bank A passes down the tubes A1 into

Fig.1.

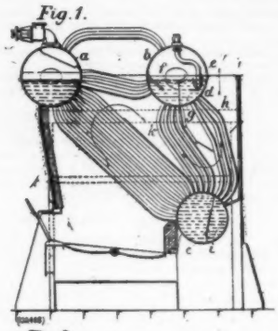
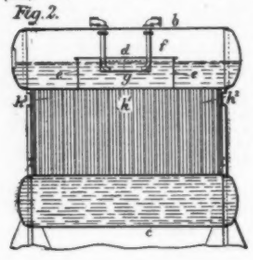


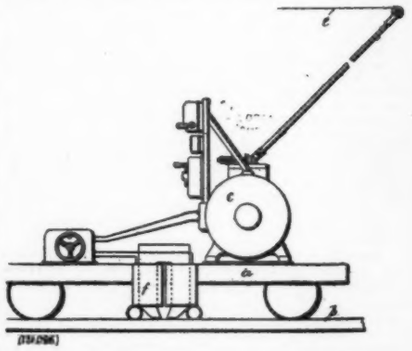
Fig.2.



the lower drum and by reason of the position of the imperforate diaphragm i passes up the tubes k^2 and k^3 of the rear bank which are cut off from the feed compartment g into the rear upper drum b, thence down into the lower drum through the tubes of the bank k in front of the imperforate diaphragm i, and thence up the front bank l to the front upper drum a. (*Accepted August* 13, 1919.)

RAILWAYS AND TRAMWAYS.

131,096. W. M. Mordey, Westminster, London. Heat Treatment of Tramway Rails. (2 *Figs.*) May 8, 1918.—It is known that the wearing surfaces of tramway rails can be hardened and toughened and the wearing properties thereof improved, by heating the rails to a sufficient temperature and depth and cooling them at a moderate rate. The present invention has for its object to enable the heating of tramway rails to a high temperature to be effected in a simple, quick and convenient manner to enable the physical condition of such rails to be altered and improved. For this purpose, successive portions of a tramway rail are heated by bringing them one after the other into the magnetic circuit of an alternate current electromagnet f, which may be one-phase or multi-phase, so constructed and of such strength, that an alternating magnetic flux will be induced in each portion of the rail under treatment, of sufficient value to set up eddy currents therein of such strength, aided to some extent by magnetic hysteresis, as to heat the metal composing it to the temperature required, but not to a temperature exceeding the critical non-magnetic temperature of the particular metal of which the rail is composed, use being made, for this purpose, of the fact that at this point, the generation of heat will auto-



matically cease to increase owing to the permeability of the heated material being then very considerably reduced. Each portion of rail, after being heated to the desired temperature, is suitably cooled to impart thereto the desired characteristic. On a vehicle a suitable for running on the tramway b, is mounted a rotary transformer or motor generator c, that receives direct current from the trolley wire e, and converts it into alternate current. Carried by the vehicle a and supported immediately above each of the rails b, is a powerful laminated alternate-current electromagnet f, having its poles close to the rail. Means are provided for adjusting the position of the magnet to suit requirements for working and transport. The winding or windings of this electromagnet are traversed by the alternating current or currents received from the rotary transformer, and alternating magnetic flux being thereby induced in the head of the rail b under and between the poles of the electromagnet, the magnetic circuit being completed locally through the head of the rail. As a consequence of this, the portion of the rail so acted on is heated by eddy currents and to some extent by magnetic hysteresis. The poles may be tapered to concentrate the induction. (*Accepted August* 27, 1919.)